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LABORATORY SAMPLING GUIDE

Capt Tiffany R. Heline

11 May 2012

Air Force Research Laboratory
711th Human Performance Wing
USAF School of Aerospace Medicine
Occupational & Environmental Health Dept
Risk Analysis Division
2510 Fifth St.
Wright-Patterson AFB, OH 45433-7913

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14. ABSTRACT

This sampling guide is designed to aid base-level Bioenvironmental Engineers (BEs) in submitting industrial hygiene, environmental health, and radiological samples to the United States Air Force School of Aerospace Medicine, Occupational and Environmental Health Department, Analytical Services Division. Effectively collecting and analyzing samples in conjunction with a health risk assessment is one of the 10 primary BE capabilities. This guide is intended to aid in this primary capability by providing information on the collection, handling, and analysis of samples submitted to the Analytical Services Division laboratories at Wright-Patterson AFB, OH. Specific guidance is also provided for overseas guidance for Pacific Air Forces locations using USAFSAM Detachment 3 laboratories and for Air Force Central Command locations using the U.S. Army Public Health Command-Europe laboratories.

15. SUBJECT TERMS

Occupational health, environmental health, radiation, dosimetry, air sampling, water sampling, soil sampling, Occupational and Environmental Health Site Assessment (OEHSA), industrial hygiene, health risk assessments, site assessments, radioanalysis, Defense Occupational and Environmental Health Readiness System (DOEHRS), customer support, analytical method, sample plan development, collection volumes, sample media, reporting limits, Automated Sampling Guide (ASAGE), field blanks, quality assurance, turnaround time, sample submission forms, AF Form 2753

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Table of Contents

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

FOREWORD

The 10 Bioenvironmental Engineering (BE) Primary Capabilities are:

1. Execute Surgeon General related vulnerability assessments
2. Conduct predictive exposure assessments
3. Evaluate/approve potable and non-potable water systems/sources
4. Execute Occupational and Environmental Health Site Assessments (OEHSA)
5. Identify Occupational and Environmental Health (OEH) hazards
6. **Analyze OEH hazards**
7. Control OEH hazards
8. Respond to OEH threats
9. Associate exposure with affected personnel
10. Assist with health risk management

The purpose of this technical guide is to provide the tools necessary for all BE personnel to meet Primary Capability 6, Analyze OEH hazards. However, effectively analyzing industrial, environmental, and radiological health hazards can reach across several of the BE primary capabilities. This technical guide provides specific technical information to assist BE personnel in sample collection and laboratory analysis. This guide does not address direct reading sampling and instrumentation.

The United States Air Force School of Aerospace Medicine, Occupational and Environmental Health Department, Analytical Services Division (USAFSAM/OEA) Laboratory Sampling Guide is designed to provide a customer friendly reference for using the Analytical Services laboratories. This sampling guide supersedes AL/OE-TR-1994-0136 Armstrong Laboratory Services Guide (1994) and USAFSAM/OEHHL Radioanalyses Laboratory Sample Guide Version 3.0 (2009). The guide is designed in Adobe Acrobat Reader 10 PDF with embedded hyperlinks to external websites, email addresses, download links, and internal bookmarks for ease of use.

Disclaimer

The Analytical Services Sampling Guide is provided in uncontrolled (customer use) format. Due to the wide geographic distribution and turnover in customers, USAFSAM does not maintain a list of recipients and does not automatically provide updated copies. The contents of the sampling guide are subject to change based on method revisions, updates, or changes. The Analytical Services Division is not responsible for any sampling error incurred by the customer. Any mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Visit the Environment, Safety, and Occupational Health (ESOH) Service Center on the Knowledge Exchange to ensure you are using the current revision of the Analytical Services Laboratory Sampling Guide.

CONTACTING USAFSAM ANALYTICAL SERVICES DIVISION

	USAFSAM/OEA WRIGHT-PATTERSON AFB, OH	USAFSAM DET 3 KADENA AB, JPN
TELEPHONE	**DSN: 798-2523** **Comm: 937-938-2523** *Monday – Friday* 0730 – 1700 Eastern	**DSN: 315-632-8275** **Comm: 011-81-611-732-8275** *Monday – Friday* 0730 – 1630 Japan Std Time
EMAIL	USAFSAM/OEHTA_Analytical@wpafb.af.mil	det3.usafsam@kadena.af.mil
INTERNET	https://kx.afms.mil/ChemLab	https://kx.afms.mil/det3kadena
SAMPLE SHIPMENTS	*Chemistry Lab* USAFSAM/OEA Attn: Chemistry Lab 2510 Fifth Street, Bldg 20840, W327N Wright-Patterson AFB, OH 45433 *Radioanalytical Lab* USAFSAM/OEA Attn: Radioanalytical Lab 2510 Fifth Street, Bldg 20840, W331 Wright-Patterson AFB, OH 45433 *Dosimetry Lab* USAFSAM/OEA Attn: Dosimetry Lab 2510 Fifth Street, Bldg 20840, W329B Wright-Patterson AFB, OH 45433	*APO* USAFSAM DET 3/AD Attn: Sample Receiving Unit 5213 Bldg 853 APO AP 96368-5213 *Commercial* Det 3 USAFSAM AD Unit 5213 Bldg 853 Kadena AB Okinawa, Japan 904-0020

SECTION 1: INTRODUCTION TO ANALYTICAL SERVICES

1.0 Introduction

This sampling guide is designed to aid base-level Bioenvironmental Engineers (BEs) in submitting industrial hygiene, environmental health, and radiological samples to the United States Air Force School of Aerospace Medicine, Department of Occupational and Environmental Health, Analytical Services Division (USAFSAM/OEA).

1.1 Summary

Effectively collecting and analyzing samples in conjunction with a health risk assessment is one of the 10 primary BE capabilities. This guide is intended to aid in this primary capability by providing information on the collection, handling, and analysis of industrial hygiene, environmental health, and radiological samples submitted to the Analytical Services Division laboratories at Wright-Patterson Air Force Base (WPAFB), OH. Radiation dosimetry details in this guide are limited to shipping and handling information; for specific guidance on radiation dosimetry, refer to Air Force Manual (AFMAN) 48-125, *Personnel Ionizing Radiation Dosimetry*. Overseas guidance is provided in Appendix A for Pacific Air Forces (PACAF) locations using USAFSAM Detachment 3 (Det 3) laboratories and Appendix B for Air Force Central Command (AFCENT) locations using the U.S. Army Public Health Command-Europe (USAPHC-Europe) laboratories.

1.2 Mission Statement

The mission of the Analytical Services Division is to serve the best interests of the USAF and the individual war fighter by providing analytical chemistry and related consultative support for USAF-wide occupational, environmental, and radiation health surveillance. Analytical Services ensures that customer quality and timeliness needs are met through in-house and contract lab services. The lab maintains a robust in-house Quality Assurance Program, including audits of contract laboratories to ensure credibility of all results. The lab provides consultative support regarding sample collection, analysis, and data interpretation. Analytical Services also provides reliable data warehousing of historical sample results.

1.3 Summary of Services

USAFSAM/OEA provides the following laboratory services:

- Chemistry Lab, including industrial hygiene and environmental chemistry
- Radioanalytical Lab
- Radiation Dosimetry Lab

A list of American Industrial Hygiene Association (AIHA) accredited analyses available through USAFSAM/OEA is included in Appendix C. The lab may be able to accommodate other requests through qualified contract laboratories or, if projected sample load is significant, through in-house method development. Implementation and validation of new procedures are time-consuming and usually require 6 months to a year or more to complete.

1.4 References

Refer to the bibliography in Appendix D for a list of publications that provide information about other areas of interest to USAFSAM customers, such as regulatory requirements and sample collection techniques. These references include, but are not limited to, other USAFSAM technical guides and pertinent regulatory documents.

1.5 Defense Occupational and Environmental Health Readiness System (DOEHRS) Tutorials

All DOEHRS screen shots and tutorials are contained in Appendix E. For quick access to a related tutorial, click the DOEHRS icon throughout the guide to be directed to the applicable section in the appendix. The DOEHRS tutorials in this guide assume a basic understanding of DOEHRS and are designed to aid in specific sampling discussions. For basic user guidance, refer to *AFRL-SA-BR-MN-2009-0001, Defense Occupational and Environmental Health Readiness System (DOEHRS) Guidance* on the Environment, Safety, and Occupational Health (ESOH) Service Center website.

1.6 Lists of Symbols, Abbreviations, and Acronyms

The glossary in Appendix F explains the symbols, abbreviations, and acronyms used in this guide. Refer to Appendix G for a listing of industrial hygiene equations.

1.7 Quality Assurance Policy

Analytical Services is committed to providing the highest quality and legally defensible analytical data in a timely and efficient manner. The process begins with initiation of a customer request, followed by sample(s) receipt, processing, sample preparation, laboratory testing, delivery of final reports, data archiving, and concluding with sample disposition. The validity and reliability of all the information generated are ensured by strict adherence of personnel to documented quality control (QC) and quality assurance (QA) protocols throughout the entire process.

1.8 Accreditations

The Analytical Services Division maintains accreditation by third party organizations to both national and international standards (Table 1). The scope of testing for these accreditations covers environmental, occupational health, and radiation dosimetry. A complete list of Industrial Hygiene Laboratory Accreditation Program (IHLAP) and Environmental Lead Laboratory Accreditation Program (ELLAP) accredited fields of testing can be obtained by referring to Appendix C or by visiting the AIHA Laboratory Accreditation website. The complete list of equipment the Radiation Dosimetry Lab is accredited to process can be accessed by visiting the National Voluntary Laboratory Accreditation Program website.

Table 1. Analytical Services Laboratory Accreditations

Industrial Hygiene and Environmental Chemistry Lab	
Accrediting Body:	American Industrial Hygiene Association (AIHA)
Accreditation:	IHLAP and ELLAP
Lab ID:	101490 (WPAFB, OH) 101802 (Det 3, Kadena AB, Japan)
Radiation Dosimetry Lab	
Accrediting Body:	National Institute of Standards and Technology (NIST)
Accreditation:	National Voluntary Laboratory Accreditation Program (NVLAP)
Lab Code:	100548-0 (WPAFB, OH)

1.9 Contract Work

It is essential to coordinate any potential contract analytical work with the lab during the *planning* phase. Any potential hurdles to obtaining commercial analytical services can usually be preempted if sampling strategies are discussed with Customer Service prior to sample collection. USAFSAM/OEA maintains blanket purchase agreements with several commercial labs to provide access to additional analytical methods not performed in-house. Analytical Services is funded through the Defense Health Programs (DHP) to provide commercial services on a limited basis (excluding most routine drinking water). Please contact Customer Service prior to sample collection for approval and coordination of commercial lab analyses.

The laboratory can also assist in ensuring samples are sent to accredited laboratories, including drinking water labs. While AIHA industrial hygiene laboratory accreditations are nationally recognized, labs must be certified in each state for Environmental Protection Agency (EPA) compliance sampling. The laboratory QA personnel can assist in locating a certified lab to meet your local sampling requirements.

1.10 Customer Satisfaction

USAFSAM/OEA values you as a customer. Customers are encouraged to leave feedback on the Analytical Service's Interactive Customer Evaluation (ICE) site. The laboratory QA team reads and discusses each survey. Feedback is an essential part of the customer-lab relationship and allows superior performance to be commended and deficiencies to be mitigated. Customer comments can be left at any time (e.g., following a phone consult with a Customer Service representative, after receiving final results, etc.) for any laboratory by completing an ICE comment card.

1.11 Automated Sampling Guide

The Analytical Services Division provides an online application to aid in industrial hygiene and environmental health sample plan development. The Automated Sampling Guide (ASAGE), available on the Chemistry Lab's website, is an online application linked directly to the Laboratory Information Management System (LIMS), which provides method-specific details including handling, stability, media, and reporting limits based on the analyte of concern. ASAGE will list all available methods for a given analyte and indicate the preferred in-house method. Please call Customer Service if an analysis other than the preferred in-house method is

required. ASAGE is limited to industrial hygiene and environmental chemistry at the WPAFB lab; it does not currently support the radioanalytical lab or Det 3.

1.12 Turnaround Time (TAT)

Analytical Services strives to provide results in a timely and efficient manner. Laboratory TAT is defined as the time from receipt of samples at the laboratory performing the analysis to the release of analytical data. In the event the laboratory is unable to meet the published TATs, you will be contacted by laboratory personnel with an explanation and a new projected TAT. The standard TATs, excluding Federal holidays, for different sample types are listed in Table 2.

Table 2. USAFSAM Turnaround Times (Business Days)

Type of Sample	***USAFSAM/OEA WPAFB, OH*** *(days)*	***USAFSAM Det 3 Kadena AB, Japan*** *(days)*
Industrial Hygiene	10	20
Environmental	10-20 *Depending on method*	20
Radioanalysis	25-60 *Depending on method*	NA
Dosimetry	5 *Monthly reports* 10 *Quarterly reports*	NA

1.13 Priority Requests

Analytical Services strives to meet base level demands for quick turnaround times. However, any priority requests should be based on an acute health risk or an excessive mission impact if delayed. Please coordinate with Customer Service ***prior*** to shipping samples if results are required sooner than the standard TAT. A written justification will be required. Analytical Services will review the lab's capacity, capabilities, customer's time requirements, certification requirements, logistics, method hold times, and subcontract funding (if applicable) when approving priority requests.

1.14 Sample Submission Procedures

Sample submissions must be accompanied by a complete sample submission form. The standard industrial hygiene sample submission form is the DOEHRS Discoverer Viewer Sample Submission workbook. Environmental health samples not analyzed in-house may require the use of sample submission forms generated by the commercial lab; contact Customer Service for additional details. Radiological sample submissions should be accompanied with a completed AF Form 2753 for environmental, radiological, and biological samples as applicable. Refer to Appendix E for DOEHRS sample submission procedures and Appendix H for AF Form 2753 sample submission procedures. All sample submission paperwork should be clearly labeled with the base code of the sender; refer to Appendix I for a complete listing of base codes.

If samples are collected incorrectly and/or incompletely documented, every effort will be made to obtain the necessary information to convert the invalid sample into a valid sample. For a quick laboratory TAT, please ensure samples are collected according to this guide and shipped appropriately and the submission forms are correct and complete**.**

1.14.1 Shipping and Handling Procedures. To ensure prompt delivery, the most expedient method is to ship samples Federal Express (FedEx®) priority overnight for shipments to the WPAFB lab and DHL for the Det 3 lab. Shipping addresses are listed in Table 3.

Table 3. Shipping Addresses

USAFSAM/OEA *WPAFB, OH*	**USAFSAM** *Det 3, Japan*
Industrial Hygiene Samples USAFSAM/OEA Attn: Chemistry Lab 2510 Fifth Street, Bldg 20840, W327N Wright-Patterson AFB, OH 45433	*APO* USAFSAM DET 3/AD Attn: Sample Receiving Unit 5213 Bldg 853 APO AP 96368-5213
Radioanalytical USAFSAM/OEA Attn: Radioanalytical Lab 2510 Fifth Street, Bldg 20840, W331 Wright-Patterson AFB, OH 45433	*Commercial* Det 3 USAFSAM AD Unit 5213 Bldg 853 Kadena AB Okinawa, Japan 904-0020
Dosimetry USAFSAM/OEA Attn: Dosimetry Lab 2510 Fifth Street, Bldg 20840, W329B Wright-Patterson AFB, OH 45433	

If FedEx® or DHL services are not available at your location, samples may also be shipped at the base's expense using a different carrier. Sample stability and hold times must be considered if shipping by any means other than overnight. Hand-carried samples should be delivered to USAFSAM prior to 1400 hours Monday through Friday to ensure samples are processed into the LIMS. Refer to Table 4 for additional guidance on sample shipping methods.

Table 4. Sample Shipping Methods

Sample Shipment Methods	
- *With long holding times* - *Not requiring refrigeration*	- *For immediate or emergent analysis* - *With short hold times* - *That must be refrigerated*
Can be sent by	***Must be sent by***
✓ Commercial Carrier - FedEx®, UPS®, DHL®, etc. ✓ Hand Carry ✓ Traffic Management Office ✓ U.S. Postal Service	✓ Overnight service via Commercial Carrier - FedEx®, UPS®, DHL®, etc. ✓ Hand Carry
Check with the carrier to ensure delivery date!	

Hazardous Materials. Hazardous materials are articles or substances that are capable of posing a risk to health, safety, property, or the environment. A list of hazardous materials can be accessed

from the International Air Transport Association (IATA) Dangerous Goods Regulations Manual or 49 CFR Part 172, Section 101 *Hazardous Materials Table*. The shipper must comply with any regulatory requirements such as proper labeling and packing. All labels and forms must be complete, legible, and accurate. Personnel must be trained and certified to ship hazardous materials.

The U.S. Department of Transportation (DOT) provides regulations governing the transport of hazardous materials under the Hazardous Materials Transportation Act of 1974. The applicable requirements of the regulations are found in 49 CFR Parts 171 through 177. The shipper should particularly note DOT regulations in the following areas:

- Marking and Labeling - 49 CFR part 172
- Placarding - 49 CFR part 172
- Monitoring - 49 CFR part 172
- Packaging - 49 CFR part 173
- Transportation by Rail - 49 CFR part 174
- Transportation by Air - 49 CFR part 175
- Transportation by Vessel - 49 CFR part 176
- Transportation on Public Highways - 49 CFR part 177

Dry Ice. The most routinely encountered hazardous material used during USAFSAM sample shipments is dry ice (carbon dioxide solid, UN 1845). Dry ice is classified as a Class 9 – Miscellaneous Dangerous Goods and must be in packaging designed and constructed to permit the release of carbon dioxide gas to prevent the buildup of pressure that could rupture the packaging. When shipping with dry ice (Figure 1), you must provide correct identification, classification, markings, and labeling on your outer carton to comply with current IATA regulations. The following permanent markings are required on the outer packaging of all IATA dry ice shipments:

- "Dry Ice" or "Carbon Dioxide Solid"
- UN 1845
- Net weight of dry ice in kilograms
- Name and address of shipper
- Name and address of the recipient

Figure 1. Dry Ice Label
Label may be printed by going to fedex.com

Liquid Shipments. Place an adsorbent in the shipping container when shipping liquids. This is absolutely necessary if any samples contain, or are suspected of containing, hazardous material. Be sure to include enough material to absorb all the liquid in the shipment if sample leakage occurs. Any leakage from the container will halt the transportation by the carrier.

Temperature-Sensitive Shipments. To prevent sample degradation, some methods require samples be shipped cold (i.e., ice packs) or frozen (i.e., dry ice). Use refrigerants and a cooler, when necessary, to maintain the samples at the temperature required for special handling and shipping. Store the samples in the refrigerator or freezer until just prior to packing. Use pre-frozen gel blocks whenever possible. Do not allow blocks to come in direct contact with the samples. Keep samples and gel blocks sealed in one or more plastic bags. Always send for next-day delivery when shipping temperature-sensitive samples and do not ship on Fridays; OEA is unable to accept Saturday deliveries for routine shipments.

Routine Shipments. For routine air sample shipments (i.e., no special shipping/handling requirements), samples should be placed in a plastic bag then in a cardboard box (Figure 2). Pack the samples securely to avoid any rattle or shock damage. Packaging material (bubble wrap, foam peanuts, etc.) can be added to limit sample mobility within the box. The sample submission paperwork should be inserted into the box and not inside the same plastic bag as the samples.

The plugs used to cap air cassettes and sorbent tubes often fall off during shipping. Sealing the caps or plugs with Parafilm® or 3M scotch tape® can increase the chance the samples will still be capped when they arrive at the lab and reduce the potential for contaminant loss and cross contamination. Care should be taken to ensure the tape is contaminant free (e.g., do not use tape with toluene in the adhesive if you are looking for toluene). Parafilm® is preferred.

Priority samples delivered after duty hours on week days, weekends, or holiday delivery ***must*** be coordinated with Customer Service in advance of the requested delivery date.

Figure 2. Sample Packaging and Shipping

Additional contaminant/analytical method specific shipping and sample preservation requirements can be found by referring to the individual method, ASAGE, or by calling Customer Service.

1.14.2 Labeling Requirements. All samples submitted for lab analysis shall be properly labeled with a unique identifier [i.e., DOEHRS sample identification (ID)]. Sample IDs shall contain no more than 13 characters, and each physical sample ID shall correspond to an ID on the sample submission paperwork. Following strict QC protocols, the lab is required to receive customer approval prior to modifying any IDs on submission paperwork/physical samples even if it is obvious a transcription error occurred. All discrepancies in sample IDs must be resolved prior to the lab proceeding with analysis. Incorrectly labeled samples will delay analysis and extend TAT.

1.14.3 DOEHRS Sample Submission Forms. The standard industrial hygiene sample submission paperwork should be the DOEHRS Discoverer Viewer – "*USAFSAM Sample Submission*" workbook. The 1-page workbook allows the base to enter data in DOEHRS without copying it to an AF Form 2750 and provides all the pertinent information required by the lab for sample processing. Appendix E has detailed instructions for accessing and printing the sample submission workbook. Refer to the DOEHRS Technical Guide for general assistance in entering samples into DOEHRS. For PACAF locations without access to DOEHRS, refer to Appendix A for the alternative Det 3 sample submission form.

1.14.4 Base Level QA/QC Procedures. To maximize sample validity and timeliness of results, it is recommended sample submissions undergo a base level QA/QC process prior to shipping to the lab. For each physical sample, there should be a corresponding sample ID on the sample submission paperwork. The QC process should include, as a minimum, a review of sample collection dates, volumes, IDs, media, requested analyte/analytical method, and base contact information as applicable. It is recommended detailed QA/QC procedures be part of a base level sampling standard operating procedure. A template QC checklist has been included in Appendix J for reference. The template is designed as an example industrial hygiene QC protocol; however, additional QC protocols for radiation and environmental samples may be developed and included in base level standard operating procedures.

1.15 Chain of Custody

If necessary, samples can be handled as if they are of an evidentiary nature. The possession of samples must be traceable from the time the samples are collected until the analysis is completed and the samples are released for disposal. Samples that do not require refrigeration and are not time sensitive should be sent by the *U.S. Postal Service using Registered Mail with a Return Receipt Request* to ensure a proper chain of custody. A formal chain of custody is normally required only when the data generated from analysis of the samples are required for adjudication. If a legally defensible "chain of custody" is required, please contact Customer Service for detailed discussions on sample labeling, packing, and shipping procedures.

1.16 Sample Receipt and Processing

Upon receipt at USAFSAM, the samples and associated paperwork will be reviewed. After verification of the sample integrity, the samples will be processed into the LIMS and receive a unique laboratory workorder number. Lab personnel will make every effort to notify the individual listed on the submission form of any deviation from requirements (holding time exceeded, temperature not met, etc.) that may compromise the analytical results. If the condition of the submitted sample does not allow the generation of valid analytical data (for example, the use of incorrect sampling media or the hold time has been exceeded), the lab will inform you that the workorder has been canceled.

1.17 Reporting

Final reports will not be released until reviewed and verified by the appropriate Technical Manager or Function Chief or their authorized designee. Final reports are typically sent via electronic mail (e-mail) to the individuals identified on the sample submission paperwork. Reports may be sent to multiple individuals by listing additional names in the comments section of the DOEHRS sample submission form. Copies of archived reports may be obtained by submitting a written request (e-mail) to Customer Service.

Sample submissions requesting multiple analytical methods will often be split into multiple workorders and reported separately as each individual method is completed. For example, a single shipment containing five hexavalent chromium [Cr(VI)] samples and five JP-8 samples will be reported in two separate reports/emails as soon as each workorder is complete.

1.17.1 Levels of Reporting. Analytical Services provides several levels of laboratory reports, including:

Level 1: This is a report consisting of analytical results for the associated methods, cover page, case narrative, and scanned analysis request form. This is the standard laboratory report provided by USAFSAM to most customers. Higher level lab reports are only provided on an as-needed basis.

Level 2: This is a Level 1 report that also includes the batch quality control sample results.

Level 3: This is a Level 2 report that also includes most aspects of the analytical run, such as instrument calibration data, tune data, prep logs, analysis logs, and instrument quality control data.

Level 4: This is a Level 3 report that also includes the raw data for the analyses involved. The raw data incorporate the printouts from the instruments, such as chromatograms.

1.17.2 Disclaimers. The lab recognizes that there are field situations when samples cannot be collected according to required sampling methods. In such cases, the laboratory will usually analyze the sample if collected on appropriate sampling media and report results, possibly accompanied by one of the example disclaimer statements listed in the comments section of the final report:

INSUFFICIENT AIR VOLUME: The sampled air volume is less than recommended for this method.

QUESTIONABLE FLOW RATE: The flow rate differs from the recommended method's rate.

INCORRECT SAMPLE MEDIA: The sample media is not currently recommended by NIOSH/OSHA.

BLANKS NOT SUBMITTED: No field blank was submitted as required by the analytical method.

HOLD TIME EXCEEDED: Samples were received outside the method recommended hold time.

1.17.3 Narrative Comments. It is particularly important to note any comments included in the narrative of the final report. Any issues that occurred with sample shipment, receiving, analysis, or QC will be annotated in the comments section and could jeopardize the validity of a result for a health risk or compliance assessment.

1.18 Chemical and Biological Warfare Agents

Samples suspected to be contaminated with or collected from areas suspected to have been previously contaminated with chemical or biological agents ***must*** be **SCREENED** and found to be **NEGATIVE** prior to shipment to USAFSAM. The negative screening results should be clearly documented on the sample submission paperwork accompanying the samples. ***Do not send samples known to be contaminated with chemical or biological agents.*** USAFSAM is not designed to handle suspected chemical or biological warfare samples. Bases should refer to the Laboratory Response Network (LRN) managed by the Centers for Disease Control and Prevention for a listing of national (biological warfare) and LRN-C (chemical warfare) Level 1 laboratories. The LRN is designed to develop, maintain, and strengthen an integrated national and international network of laboratories that can respond quickly to the needs for rapid testing,

timely notification, and secure messaging of results associated with acts of biological and chemical terrorism.

1.19 Funding

There is no direct cost to base level BEs for the use of USAFSAM Analytical Services. USAFSAM/OEA is DHP funded to cover the cost of in-house and contracted analyses. Exceptions to this policy include AF drinking water program analyses and sampling at locations outside the contiguous United States (OCONUS). AF drinking water program funding is sent directly to the medical treatment facilities for local execution. For PACAF and AFCENT locations, refer to Appendix A and Appendix B, respectively, for additional details regarding OCONUS funding.

Even though USAFSAM/OEA is not funded to cover most routine drinking water analyses, a blanket purchase agreement (BPA) has been established with laboratories that are certified in most CONUS states. If necessary, base level personnel may request use of the BPA if local funding is available.

1.20 Analytical Services Organizational Structure

The Analytical Services Division is organized into two branches and six sections as indicated by the organization chart in Figure 3. All customer questions and inquiries should be addressed to the Customer Service section in the Analysis Support Branch (OEAS).

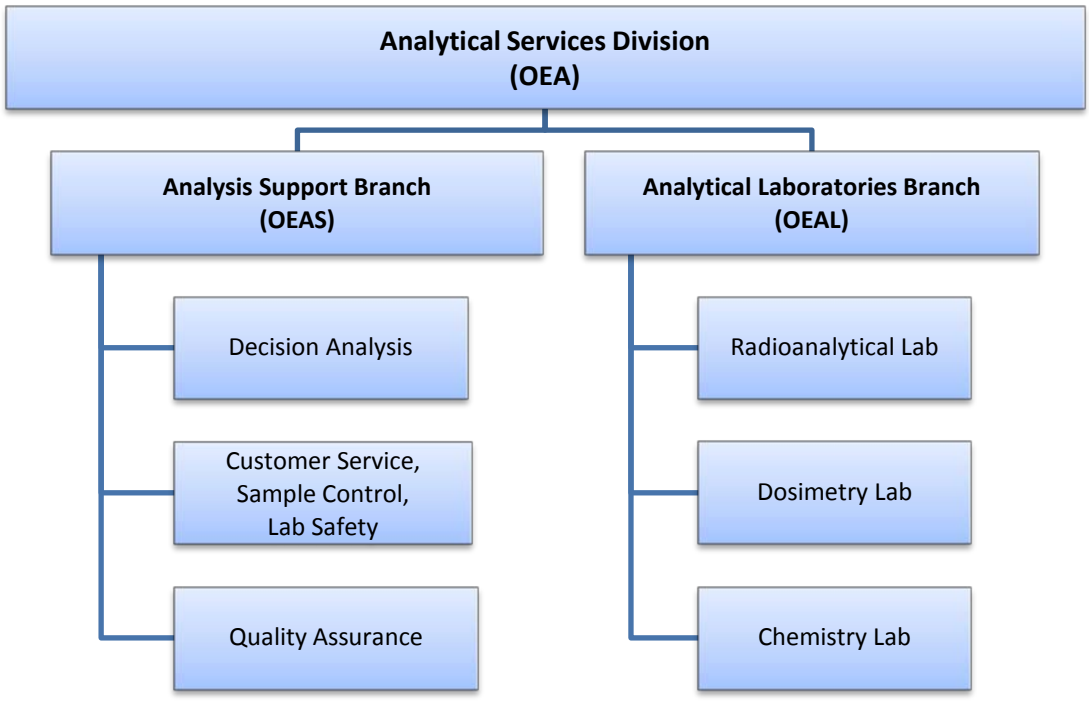


Figure 3. Analytical Services Organizational Structure

1.21 Analytical Services Customer Support

Analytical Services provides several means of support to address sampling questions. ASAGE is designed to be the first stop, self-service site to address basic industrial hygiene and environmental sampling and analysis questions. Beyond ASAGE, laboratory Customer Service personnel and the ESOH Service Center are available for telephone consultation (Table 5). Technical questions may be referred to the appropriate analyst or function chief within the lab for additional information. Refer to Figure 4 for a detailed look at the USAFSAM sampling and analysis process.

Table 5. Customer Support Services

CUSTOMER NEED	**CUSTOMER SERVICE** *WPAFB DSN 798-2523 DET 3 DSN 315-632-8275*	**ESOH SERVICE CENTER** *DSN 798-3764*	**ASAGE WEBSITE**
Selecting appropriate analytical method	**X**	**X**	**X**
Requesting rush analyses	**X**		
Technical information on analyses	**X**		
Reprint of historical results	**X**		
Sample collection procedures	**X**	**X**	**X**
Shipping guidance	**X**		**X**
Sample processing/final report status	**X**		
Sample plan development		**X**	
Appropriate occupational and environmental exposure limit recommendations		**X**	
Sample collection volumes/flow rates			**X**
Reporting limits	**X**		**X**
Analytical Error	**X**		

Note: ASAGE does not support the Radioanalytical Lab or Det 3.

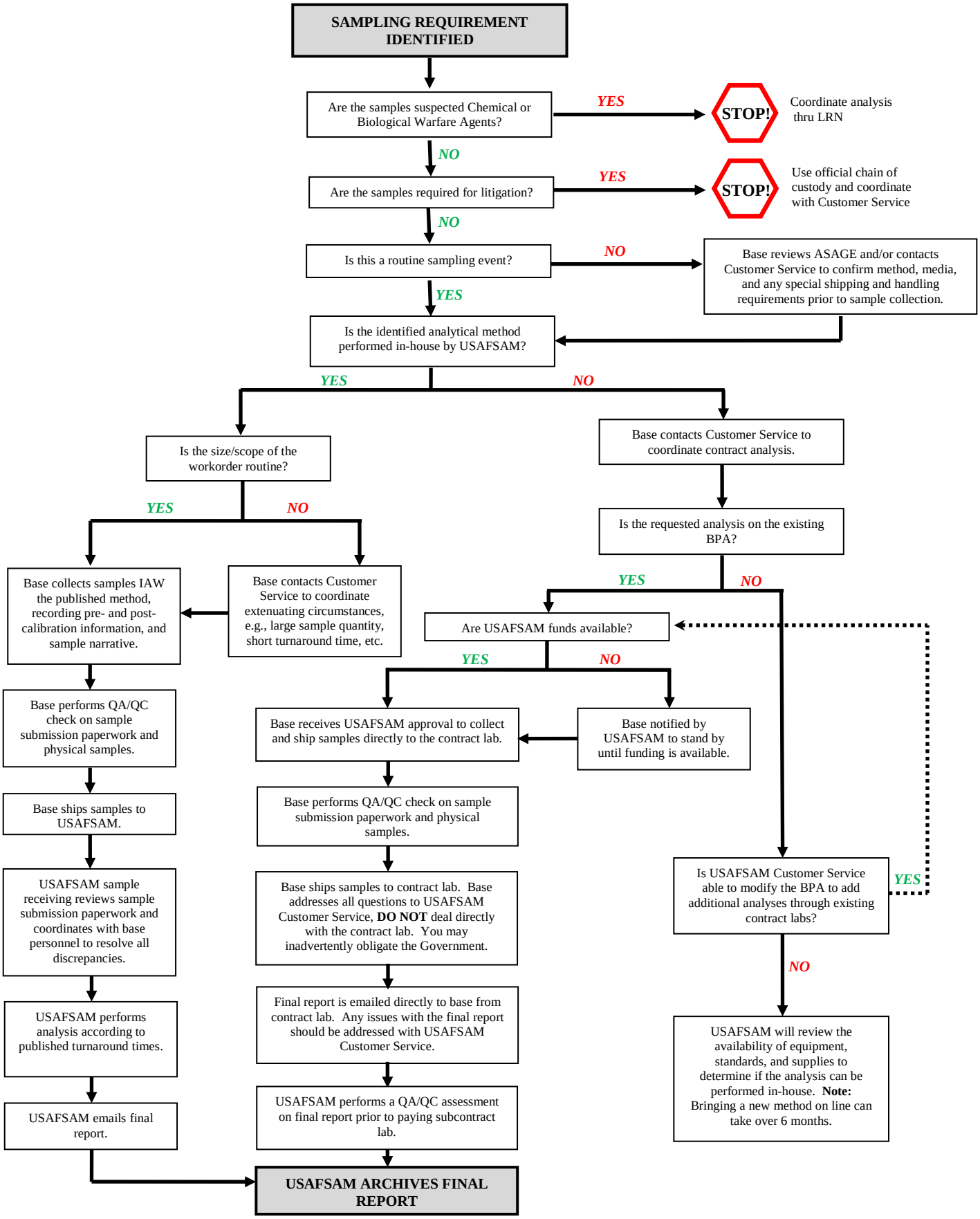


Figure 4. USAFSAM Sampling and Analysis Flowchart

SECTION 2: OCCUPATIONAL HEALTH SAMPLING & ANALYSIS

2.0 Occupational Health Sampling

Occupational health samples are generally collected in conjunction with a health risk assessment (HRA) of hazards generated in the industrial workplace. Personal breathing zone samples are typically collected referencing American Conference of Governmental Industrial Hygienists (ACGIH®) and Occupational Safety and Health Administration (OSHA) exposure. Occupational health samples may also be collected in nonindustrial workplaces to assess the migration of contaminants from adjacent industrial processes (e.g., fuel operations, generator exhaust, hazardous material storage area) or simply be present around the workplace.

2.1 Industrial Hygiene Services

USAFSAM Analytical Services provides a wide range of in-house analytical services through the Chemistry Lab. Table 6 provides a complete list of these services.

Table 6. Industrial Hygiene Services

Analytical Capability			WPAFB, OH USAFSAM	Kadena AB, Japan Det 3
Gas Chromatography	Mass Spectrometry	GC-MS	X	X
	Flame Ionization Detector	GC-FID	X	-
	Flame Photometric Detector	GC-FPD	X	-
	Nitrogen Phosphorous Detector	GC-NPD	X	-
	Electron Capture Detector	GC-ECD	X	X
Inductively Coupled Plasma	Optical Emission Spectrometry	ICP-OES	X	-
	Mass Spectrometry	ICP-MS	X	-
High Performance Liquid Chromatography	Ultraviolet Detector	HPLC-UV	X	-
	Fluorescence	HPLC-FL	X	-
Ion Chromatography		IC	X	-
Gravimetric Analysis		GV	X	X

2.2 Occupational and Environmental Exposure Limit Definitions

Occupational and Environmental Exposure Limit (OEEL). OEELs are limits of exposure established to protect personnel from occupational and environmental health (OEH) threats. As defined by AFMAN 48-155, *Occupational and Environmental Health Program*, the OEEL is "the most appropriate exposure limit adopted from established recognized standards including, but not limited to, those in Air Force instructions, the latest edition of the *TLV® Booklet* published annually by the American Conference of Governmental Industrial Hygienists, 29 CFR 1910.1000 Tables Z-1, Z-2, and Z-3, and 40 CFR 141." In addition to the sources listed in the AFMAN, Table 7 in Section 2.3.1 of this document provides possible sources for establishing OEELs.

Action Level (AL). As defined by AFMAN 48-155, the AL is the exposure level that dictates active air monitoring, medical monitoring, and/or employee training. The AL for airborne exposures is typically one-half the OEEL for time-weighted average (TWA) exposures except

where 29 CFR 1910 designates a different concentration or where the statistical variability of sample results indicates a lower fraction of the OEEL should be used as the AL.

Permissible Exposure Limit (PEL). A PEL is a legally enforceable occupational exposure standard established by the Federal OSHA or by a state-run program accepted by OSHA. Most PELs are time-weighted average concentrations for a normal 8-hour workday and a 40-hour work week, which shall not be exceeded. However, PELs may also be "ceiling" (C) values or "excursion limits."

*Threshold Limit Value (TLV®).*The threshold limit value is a level of airborne concentrations of chemical substances to which it is believed nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse health effects. TLVs® are established by the American Conference of Governmental Industrial Hygienists. While the OSHA PEL is legally enforceable, the TLV® is a recommendation from ACGIH® and is only a guideline. Most TLVs® are 8-hour TWA concentrations; however, a TLV® may also be a short-term exposure limit (STEL) or C.

Averaging Time. An OEEL averaging time refers to the time span for which an average exposure is estimated. The appropriate averaging time is set by the sponsor of the OEEL (OSHA, ACGIH®, etc.) and can extend from seconds and minutes to a single shift, to multiple shifts, to months and years. Four typical averaging periods are listed below:

- *8-hour TWA.* The 8-hour TWA is the time-weighted average concentration for a normal 8-hour workday and a 40-hour work week that cannot be exceeded. The most common industrial hygiene TWA duration is 8 hours, which is the length of the common workday. A TWA may be determined by a single sample or by mathematical combination of one or more consecutive samples.
- *STEL.* The short-term exposure limit is a 15-minute TWA exposure that should not be exceeded at any time during the workday. The STEL is not an independent exposure limit, but rather supplements the 8-hour TWA in cases where there are recognized acute effects from a substance whose toxic effects are primarily chronic. Exposures above the 8-hour TWA OEEL up to the STEL should not be longer than 15 minutes and should not occur more than four times per day. Also, there should be at least 60 minutes between successive exposures in this range.
- *Excursion Limit (EL).* Asbestos currently has a substance specific standard with an OSHA EL. The OSHA EL for asbestos was set as a TWA over a 30-minute period, which distinguishes it from a STEL, which has a shorter averaging period. Additional substances can be found in 1910.1000 Table Z-2 (e.g., benzene, beryllium, toluene, etc.). These substances list maximum acceptable peaks above the acceptable ceiling concentration and the allowed maximum duration. Additionally, ACGIH® states that for the vast majority of substances with a TLV®-TWA, there is not enough toxicological data available to warrant a STEL. For these substances, excursions may exceed three times the TLV®-TWA for no more than a total of 30 minutes during a workday and under no circumstances should ELs exceed five times the TLV®-TWA, provided the TLV®-TWA is not exceeded.
- *C.* A ceiling is the contaminant concentration that should not be exceeded during any part of the workday exposure. If instantaneous monitoring is not feasible, samples are collected and assessed as a 15-minuteTWA exposure. Ideally, C measurements are taken using a direct reading instrument.

Gases. Gases are substances that completely occupy a space and can be converted to a liquid or solid by increasing pressure or decreasing temperature. A gas is a chemical substance whose

molecules are moving freely within a space in which they are confined at normal temperature and pressure. Gases assume no shape or volume. OEELs for gases are typically established in terms of parts of gas per million parts of contaminated air by volume (ppm).

Vapors. A vapor is a gaseous form of a substance that is normally a solid or liquid at room temperature. The amount of vapor given off by a chemical substance is expressed as the vapor pressure and is a function of temperature and pressure. OEELs for vapors are typically established in terms of parts of vapor per million parts of contaminated air by volume (ppm).

Aerosol. Aerosols are liquid droplets or solid particles dispersed in air. Aerosols may be characterized by their aerodynamic behavior and the site of deposition in the human respiratory tract. OEELs for aerosols are usually established in terms of mass of the chemical substance in air by volume (mg/m^3). Other terms used to describe aerosols include:

- *Dust* – Solid particles generated by mechanical action (crushing, grinding, impact, etc.). Size ranges are usually between 0.1 µm and 30.0 µm.
- *Fume* – Airborne solid particles formed by condensation of vapor (e.g., welding fumes). Size ranges are usually between 0.001 µm and 1.0 µm.
- *Mist* – Suspended liquid droplets generated by atomization of bulk liquids through mechanical processes such as splashing, bubbling, or spraying. Size ranges are between 0.01 µm and 100.0 µm.
- *Fogs* – Suspended liquid droplets generated by the physical condensation of the vapor phase. These droplets are typically smaller than mechanically generated mists and range between 0.01 µm and 10.0 µm.
- *Fibers* – Elongated particulates with an aspect ratio (length to width) of 3:1.
- *Smoke* – An aerosol of fine particulate matter originating from combustion. Smoke usually contains droplets and dry particles. Size ranges are usually between 0.01 µm and 1.0 µm.

2.3 Industrial Hygiene Sample Plan Development

The first step in a successful sampling event is developing a complete sampling strategy. At a minimum, a sampling plan should start by answering the following six questions addressed below. For assistance in developing a sampling strategy, bases are encouraged to contact the ESOH Service Center.

2.3.1 Question 1: What is the sampling objective? Will the results be compared to a published OEEL; are you looking for deviations from an established baseline; has there been a change in operations, equipment, or materials driving the sampling event? *'What is the purpose of sampling?'* is the single most important question and ***MUST*** be answered prior to sampling. Bottom line: what do you intend to do with the quantitative results listed on the final report? Typical purposes for an exposure assessment include:

- Health risk assessment and management
- Compliance determination
- Management of programs that are implemented by comparison with an exposure limit
- Health complaint or air quality problem
- Future epidemiologic studies
- Task or contaminant investigation for determination of exposure control strategies
- Worker compensation/toxic tort case
- Evaluation of future changes in the workplace (e.g., introduction of a new chemical)

If the sampling objective is to compare the analytical result to an OEEL, there are several possible sources for establishing OEELs in addition to those specified in AFMAN 48-155 (Table 7). When selecting an appropriate OEEL, one should consider the underlying premises and shortcomings of the various exposure limits. All exposure limits are not fine lines between safe and dangerous levels.

Table 7. Possible Sources for Establishing OEELS of Occupational HRAs[a]

Guideline	Target	Author	Summary	Duration
IDLH	Worker	NIOSH	Highest concentration from which escape is possible without permanent damage	Was 30 minutes; revised IDLH (1994) mentions no exposure duration
TLV **PEL** **REL**	Worker	ACGIH, OSHA, NIOSH	Occupational exposure for 8-hour workday	8 hours per day, 20 to 30 years
STEL	Worker	ACGIH	Occupational short-term exposure limit	15 minutes
DNEL	Worker	Manufacturer (REACH regs)	Based upon expected use of chemical; EU req't	Varies
MEG	Military	USAPHC	Deployed exposure guidelines, TG-230	From 10 minutes to 1 year

IDLH- Immediately Dangerous to Life or Health, National Institute for Occupational Safety and Health
TLV- Threshold Limit Value, American Conference of Governmental Industrial Hygienists
PEL- Permissible Exposure Limit, Occupational Safety and Health Administration
REL- Recommended Exposure Limit, National Institute for Occupational Safety and Health
STEL- Short-Term Exposure Limit, American Conference of Governmental Industrial Hygienists
DNEL- Derived No Effect Level, European Union (EU), Registration, Evaluation, Authorization and Restriction of Chemicals
MEG- Military Exposure Guideline, U.S. Army Public Health Command, Technical Guide 230

[a]Table adapted from Eninger & Ott, *Operational Health Risk Assessment* (2011).

2.3.2 Question 2: Where are you sampling? Identify expected exposure sites. Include where chemicals are stored, transported, and used at the site, and what ventilation and airflow patterns exist. Identify the buildings, rooms, and work centers where the potential hazard will be generated.

2.3.3 Question 3: What are you sampling? This is based on available information. What are the potential chemical hazards? Refer to available material safety data sheets (MSDSs). The toxicity, exposure pathway, hazard quantity, task duration, and task frequency are factors to consider when selecting the chemical hazard to monitor. What is the physical state of the

contaminant (i.e., gas, vapor, or aerosol)? Note: If there is high probability that sampling will need to be conducted, it is recommended to request a physical copy of the MSDS of the actual product being used at the time of sampling. This will eliminate any issues with outdated information from MSDS databases.

2.3.4 Question 4: What type of sample will you collect? For compliance sampling, OSHA requires that an employee's exposure be measured by any combination of long-term or short-term samples that represent the employee's actual exposure. There are two basic types of sample collection techniques: personal breathing zone samples and area monitoring. Breathing zone samples provide the best information in determining an employee's actual exposure.

Personal Breathing Zone Samples. The sampling pump and collection device is directly attached to the employee and worn continuously during all work and rest operations. Samples are collected from the breathing zone of the employee, a hemisphere forward of the shoulders and centered at the nose, with a radius of approximately 6 to 9 inches. Personal sampling is the preferred method of evaluating worker exposure to airborne chemicals.

Area Monitoring. The sampler is placed in a fixed location in the work area (also referred to as "general air"). Samplers can be used to measure emissions from process equipment or background levels of an environmental agent. They may not be used for OSHA PEL compliance.

2.3.5 Question 5: Who are you sampling? This is based on knowledge of the potential exposure sites and the various job requirements at the site. What job classifications or specific individuals should be considered for monitoring?

Maximum Risk Employee. Workers with the greatest potential exposure must be included. The most reasonable sampling strategy, for the most efficient use of sampling resources, is to sample the employee presumed to have the highest exposure risk. The best procedure for determining the maximum risk employee is to observe and select the employee closest to the source of the hazardous material being generated. Worst-case monitoring data must be interpreted carefully because the data reflect the worst-case exposure profile; therefore, it might not reflect the actual health risk for all workers in a given similar exposure group (SEG).

Random Sampling of an SEG. If a maximum risk worker cannot be selected with reasonable certainty, then it is necessary to resort to random sampling of the SEG. The objective of random sampling is to select a subgroup of adequate size so that there is high probability that the random sample will contain at least one worker with high exposure. Table 8 gives the required sample size **n** of a random sample drawn from a group of size **N,** which ensures with 90% confidence that at least one individual from the highest 10% exposure group is contained in the sample. For more information on random sampling, refer to the AIHA publication *A Strategy for Assessing and Managing Occupational Exposures*, page 90 (2006.)

Table 8. Random Sampling of an SEG[a]

Size of Group N	Number of Required Samples
8	7
9	8
10	9
11-12	10
13-14	11
15-17	12
18-20	13
21-24	14
25-29	15
30-37	16
38-49	17
50	18

[a]**Table 3.1 from NIOSH Occupational Exposure Sampling Strategy Manual (1977)**

2.3.6 Question 6: What is the sample duration? Sample duration may vary from a few seconds to 8 hours or more. The time period for sample collection depends on a variety of factors including: the sampling and analytical method, the expected concentration of the contaminant being measured, the type of OEEL to which the sample will be compared, the number of consecutive samples to be collected on a single employee during a single work shift, and whether the work shift is longer than 8 hours. Consider the below factors in determining the appropriate sample duration.

Sampling Method. The sampling method is one factor in determining the duration of each sample. A single grab sample collected with short-term detector tubes is collected over a period of seconds to minutes. Low-flow and high-flow sampling pumps, combined with filters, impingers, and/or solid sorbent media, are used to collect longer duration samples generally 15 minutes to 8 hours. Direct reading instruments provide almost instantaneous or real-time results.

Contaminant Concentration and Analytical Method. The concentration of a contaminant in the sampled air has a large effect on the sample duration. Generally, the higher the concentration, the shorter the duration of a single sample and vice versa. Minimum sampling times aim to collect enough mass of contaminant to be above the laboratory's reporting limit. Maximum sampling times aim not to collect too much mass of contaminant to avoid sorbent breakthrough or filter overloading. For example, charcoal tubes may need to be changed more frequently to prevent breakthrough. The breakthrough time of a charcoal tube is a function of the air concentration of the contaminant being sampled, the sample flow rate, and the humidity of the environment being sampled. Breakthrough time is also a function of the type, amount, size, packing configuration of the charcoal in the tube, and competition for sorbent sites by other contaminants present in the air. Similar limits on sampling time apply to filters and impingers to prevent overloading. Judgment should be exercised in changing sampling media of any type often enough to sample a sufficient volume of air to quantify the sample without the occurrence of breakthrough.

Type of OEEL to Which the Sampling Results Will Be Compared. Samples collected for 100% of the time period for which the OEEL is defined provide the best estimate of the TWA employee exposure. Each type of OEEL imposes different sample duration requirements:

C. Samples collected to determine compliance with ceiling limits are usually taken as a series of 15-minute samples during periods of maximum expected exposure. Samples collected for comparison with ceiling limit OEELs are best taken in a non-random fashion, during periods of maximum expected concentrations. A minimum of three measurements should be taken during each work shift sampled. The highest result is the best estimate of the employee's maximum exposure for that shift. Direct reading instruments are ideal for C measurements,

STEL. STEL samples should be taken over a 15-minute period in a non-random fashion during periods of maximum expected concentration.

8-hour TWA OEELs. Evaluate the potential for employee overexposure through partial or full shift air sampling. Full shift samples should be taken to evaluate TWA exposures whenever possible and must be used when determining compliance with OSHA PELs. Full shift sampling is defined as a minimum of the total time of the shift less 1 hour (i.e., 7 hours of an 8-hour shift or 9 hours of a 10-hour work shift). However, no more than 8 hours of sample can be used in the 8-hour TWA-PEL calculation (refer to discussion on extended work shifts below). Figure 5 provides a diagram of available 8-hr TWA measurements and can be further broken down into:

- *Full Period Single Sample Measurement.* The sample is collected for the full period of the standard. This would be 8 hours for an 8-hour TWA standard.
- *Full Period Consecutive Samples Measurement.* Several samples (equal or unequal time duration) are obtained during the entire period appropriate to the standard. The total time covered by the samples must be 8 hours for an 8-hour TWA standard.
- *Partial Period Consecutive Samples Measurement.* One or several samples (equal or unequal time duration) are obtained for only a portion of the period appropriate to the standard. For an 8-hour TWA standard, this would mean the samples range from 4 to less than 8 hours. Several samples totaling less than 4 hours (as eight 30-minute samples) would probably be best described as grab (short-term) samples for the purposes of analysis.
- *Grab Samples Measurement.* Grab samples are taken at random intervals over the period of time for which the standard is defined. Each sample collection is less than 1 hour each, generally only minutes to seconds.

Extended Work Shifts. For employees working shifts greater than 8 hours, OSHA uses two approaches to determining the 8-hour TWA.

- *8-hour Continuous Sample.* Sample the worst continuous 8-hour work period of the entire extended work shift.
- *8-hour Noncontiguous Sample*. Collect multiple samples over the entire work shift. Sampling is performed so that multiple personal samples are collected during the first 8-hour work shift and additional samples are collected for the extended work shift. Unless you are dealing with lead (Pb), the employee's exposure in this approach is calculated based upon the worst 8 hours of exposure during the entire work shift. Using this method, the worst 8 hours do not have to be contiguous.

In cases where employees work an extended shift, the OEELs can be modified to take into account the increased uptake due to longer work exposures and reduced clearance time from the body because of the short time away from the work exposure. Refer to paragraph 2.16 for more information on extended work shifts.

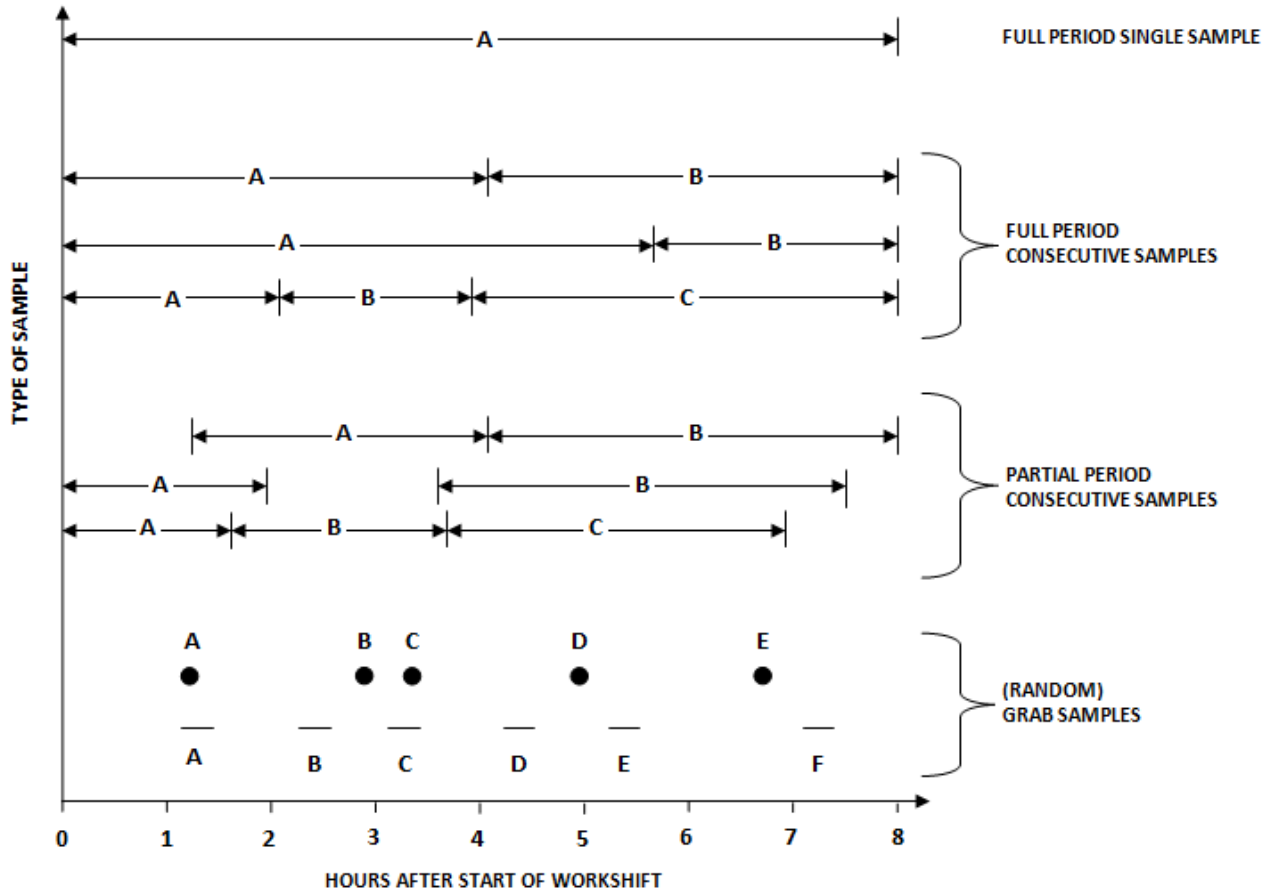


Figure 5. Type of Personal Samples

(Figure 3.1 from the NIOSH Occupational Exposure Sampling Strategy Manual)

2.4 Analytical Methods

Most analytical methods used by the Chemistry Lab for industrial hygiene are published by NIOSH, OSHA, and less frequently the EPA. Since OSHA does not require specific analytical methods, unless stated in a stressor-specific standard, any method (e.g., American Society for Testing and Materials (ASTM), scientific literature, journal articles, etc.) can be used for compliance sampling as long as it meets NIOSH criteria of accuracy of ±25% of the true air concentration at least 95% of the time. For a listing of preferred in-house analytical methods, please refer to ASAGE, Table A-1 in Appendix C, or call Customer Service.

2.4.1 OSHA Sampling and Analytical Methods. An alphabetical list of chemicals as well as a list of chemical abstract service numbers that have either a validated or partially validated OSHA method can be accessed on the OSHA Index of Sampling and Analytical Methods.

2.4.2 NIOSH Manual of Analytical Methods (NMAM). The NIOSH Manual of Analytical Methods may be searched by chemical name, chemical abstract service number, or method number. In addition to individual analytical methods, the NMAM provides guidance on quality assurance, method evaluation, biological monitoring, aerosols, and special measurement considerations. The front page of each NIOSH method summarizes sampling and measurement parameters and provides estimates of limit of detection, working range, precision, and interferences (Figure 6).

CHEMICAL NAME **METHOD #**

FORMULA Molecular Weight Chemical Abstracts Service # RTECS #

Method numbers are the same as those in the 3rd edition. Evaluation (Full, Partial, Unrated, N/A) is assigned as described in Method Classification of these "blue pages." Issue date reflects current version (e.g., August 15, 1994) and previous 3rd edition versions, if any.

OSHA : These exposure limit values are
NIOSH: those in effect at the time of
ACGIH: printing of the method.

PROPERTIES: Boiling/melting points, equilibrium vapor pressure, and density help determine the sample aerosol/vapor composition.

SYNONYMS: Common synonyms for the substance. These are all listed alphabetically in the Index of Names and Synonyms ("yellow pages" in this Manual).

SAMPLING

SAMPLER: Brief description of sampling EQUIPMENT

FLOW RATE: Acceptable sampling range, L/min

VOL-MIN: Minimum sample volume (L); corresponds to Limit of Quantitation (LOQ) at OSHA PEL

-MAX: Maximum sample volume (L) to avoid analyte breakthrough or overloading

BLANKS: Each set should have at least 2 field blanks, up to 10% of samples, plus 6 or more media blanks in the case of coated sorbents, impinger solutions, or other special samplers.

ACCURACY

Data are for experiments in which known atmospheres of the substance were generated and analyzed according to the method. Target accuracy is less than 25% difference from actual concentration over the range of the method.

MEASUREMENT

TECHNIQUE: The measurement technique used

ANALYTE: The chemical species actually measured

A summary of the measurement EQUIPMENT, SAMPLE PREPARATION, and MEASUREMENT steps appearing on the second page of the method is given here.

CALIBRATION: Summary of type of standards used

RANGE: Range of calibration standards to be used; from LOQ to upper limit of measurement (Note: More concentrated samples may be diluted in most cases to fall within this calibration range.)

ESTIMATED LOD: Limit of detection (background + 3)

PRECISION ($_r$): Experimental precision of spiked samplers

APPLICABILITY: The conditions under which the method is useful, including the working range in mg/m^3 (from the LOQ to the maximum sampler loading) for a stated air volume are given here.

INTERFERENCES: Compounds or conditions which are known to interfere in either sampling or measurement are listed.

Figure 6. Layout of Front Page of NIOSH Methods
(Summary from the NIOSH Manual of Analytical Methods, page 3)

2.5 Sample Media

Personal sampling media typically falls into three categories: filters, solid sorbent tubes, and passive monitors. Less commonly, personal sampling may require impingers and bubblers. It is important to annotate the type of media used during each sampling event. Prior to sampling, ensure the media is ***not*** expired. For questions regarding media shelf life, contact the manufacturer. The Chemistry Lab cannot extend a media shelf life. The physical state of the contaminant being sampled should be considered when determing a sampling media. It is important to choose the proper sampling media to collect all phases of the contaminant of interest. For example, some isocyanate protocols require a two-stage sampling approach. The first stage contains an untreated polytetrafluoroethylene (PTFE) filter to collect the aerosol phase and stage two holds a treated glass fiber filter to capture the vapor phase.

2.5.1 Filters. Filter sampling is used to evaluate potential airborne particulate hazards, such as dusts, fumes, and mists (Figure 7). For filter sampling, a pump is used to actively pull a known volume of air through a filter appropriate for the hazard. After the particulate matter has been deposited on the filter, the concentration (mass) of the analyte of interest can be determined by analytical methods. Filter pore size is important (e.g., a 0.8-µm pore size creates more resistance than a 5-µm pore, resulting in increased velocity, impact, and efficiency). Care should be taken not to overload the cassette. An overloaded cassette can easily be identified by loose particulates that move freely when the filter is inverted. If the cassette is overloaded, the lab will at best only be able to provide an estimated concentration.

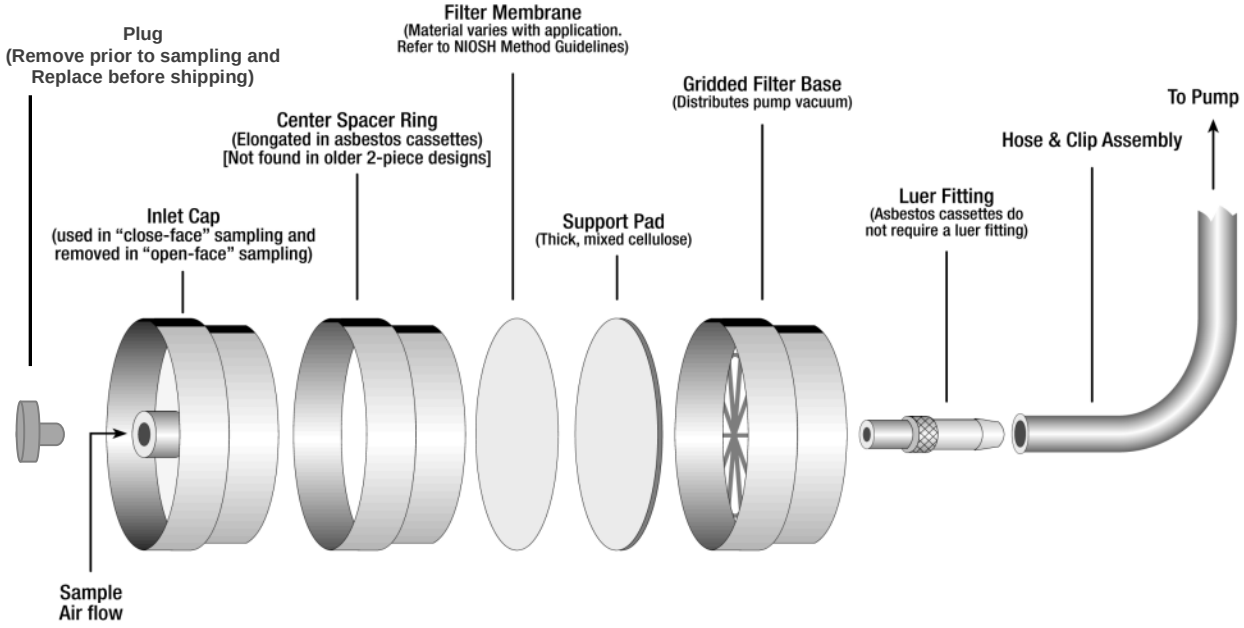


Figure 7. Air Sampling Filters
(Pictures courtesy of SKC, Inc.)

There are several types of filters used for airborne hazard sampling. The type of filter required for a specific analyte and analytical method is provided in ASAGE. Table 9 shows examples of a few types of filters and their use.

Table 9. Types of Air Sampling Filters

Filter Type	Typical Uses	
Glass Fiber Filters	Isocyanates, Oil Mists, Pesticides	
Polyvinyl Chloride (PVC)	Particulates, Silica, Hexavalent Chromium	
Mixed Cellulose Ester (MCE)	Metals, Particulates, Fibers, Asbestos	
Teflon Filter (PTFE)	Alkaline Dust, Oil Mist, Hydrogen Sulfide	
Quartz	Diesel Particulate, Elemental Carbon	

2.5.2 Solid Sorbent Tubes. Many gases and vapors are collected using solid sorbent tubes (Figure 8), consisting of a glass tube containing two sections of a solid adsorbent material. When air is actively pulled through the tube, airborne gases and vapors are adsorbed by the first sorbent section while the second section serves as a backup in case analyte breakthrough occurs. If directional arrows are present on the sampling tubes, the arrow should be pointed toward the pump. Hint: the smaller portion of the sorbent material (backup sorbent layer) is always closest to the pump. Prior to laboratory analysis, the sorbent material is removed from the sampling tubes and the analytes of interest are extracted and analyzed. The first and second sections of the sorbent tube are analyzed separately to monitor breakthrough. *Breakthrough* describes a condition in which the mass of a collected gas or vapor in the backup section is greater than 10% of the mass in the front section. This means that a significant quantity of the contaminant may not have been collected. The calculated concentration, therefore, is of questionable validity. High temperature and high humidity will increase the likelihood breakthrough will occur. The analytical lab will typically flag final results if breakthrough is suspected.

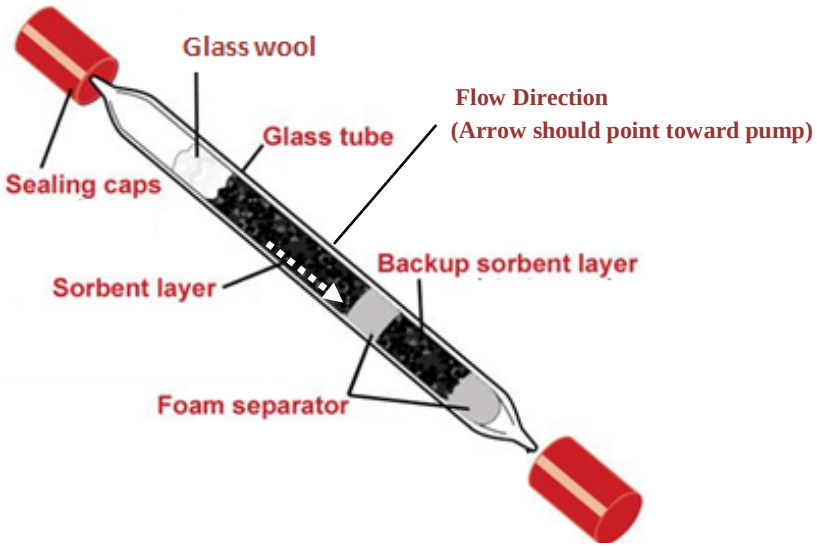


Figure 8. Air Sampling Solid Sorbent Tubes
(Pictures courtesy of SKC, Inc.)

Sorbent tubes are designed to be used in the vertical position. If a sorbent tube is positioned horizontally, sorbent material may fall to one side of the tube and allow air flow to pass more readily, reducing the absorption efficiency of the tube. There are several types of solid sorbent tubes used for gas and vapor sampling. The type of sorbent tube required for a specific analyte for each test is given in ASAGE. Table 10 shows examples of a few types of sorbent tubes and their uses:

Table 10. Types of Solid Sorbent Tubes

Tube Type	Typical Uses	
Anasorb® 747	Methyl Ethyl Ketone, Ethylene Oxide	
Charcoal Tube	Organic Solvents	
Molecular Sieve	Nitrogen Oxides	
XAD®-2	Pesticides, Polynuclear Aromatic Hydrocarbons, Amines	
XAD®-7	Glycols, Cresols, Phenol	
Silica Gel	Aliphatic Amines, Methanol, Aldehydes, Acid Mist	

2.5.3 Passive Samplers. Passive samplers do not require a sampling pump (Figure 9). They collect airborne gases and vapors at a rate controlled by a physical process such as diffusion through a static layer or permeation through a membrane without the active movement of air through an air sampler. Most commercially available passive monitors operate on the principle of diffusion. Diffusive samplers are typically small plastic enclosures filled with a granular solid sorbent such as activated charcoal that has an affinity for organic gases and vapors. One section of the enclosure is open to the air. Organic gases and vapors pass through the opening by diffusion and are adsorbed, or trapped, by the sorbent material. The diffusion occurs because molecules tend to move from an area of high concentration to an area of low concentration. If the ambient concentration of a particular gas or vapor is greater than the concentration inside the monitor, then the gas or vapor molecules will diffuse across a barrier into the monitor and be collected by a sorbent material. The rate of diffusion is determined by the manufacturer of the device. Monitoring begins when the device's cover is removed; the start time is recorded. The worker wears the monitor in his or her breathing zone. When sampling is complete, the monitor is removed and resealed and the stop time is recorded. ***Note:*** Only a few select passive monitors and analytical methods have been published and approved by OSHA. In many cases there are no OSHA or NIOSH methods to reference to ensure the reliability of data when using passive samplers.

Figure 9. Air Sampling Passive Monitors
(Pictures courtesy of SKC, Inc.)

Generally, to use a passive monitor, air movement at 25 ft/min across the face of a passive sampler is necessary for proper sampling. This condition is normally met during personal sampling on a mobile worker, but not during area sampling in calm air. "Starvation" occurs when air is stagnant at the face of a passive monitor because the boundary zone is depleted of fresh contaminant molecules. The resulting slowdown in the diffusion process decreases the effective sampling rate and produces an erroneous low measurement of concentration. Alternatively, excessively turbulent air will also disrupt normal diffusion rates. Table 11 shows examples of a few types of passive monitors and their uses:

Table 11. Types of Passive Monitors

Passive Monitor	Typical Uses	
SKC UME^{X}	Formaldehyde	
SKC 575	Organic Solvents	
SKC Ultra$^{®}$	Organic Solvents	
3M^{TM} 3500	Organic Solvents	

2.6 Sample Collection and Calibration Trains

The accuracy of final laboratory sampling results is directly dependent on the accuracy of the volume reported by field personnel. Therefore, correct sample train assembly and calibration of the pump/airflow through the sample collection device are an absolute necessity.

- *Dead Volume.* Dead volume is the gas volume between a flow generator and the instrument taking the measurement. Since gas is compressible, it can act as a spring between the flow source and the measurement instrument. For best accuracy, this volume should be kept to a minimum. According to one pump manufacturer (SKC, Inc.), the recommended tubing length on either side of the media to the pump and the calibrator should be no more than 20 inches. Refer to the specific pump manufacturer for additional specific guidance.

- *Luer Adapters.* The small plastic adapter used to connect the filter cassette to the sample collection tubing, known as the luer adapter, should not be used on the inlet side of the filter cassette during calibration. Since the adapter is only used on the outlet side during sample collection, it should be assembled in the same manner during calibration to obtain a representative flow pattern.

Refer to Figures 10 and 11 on the following pages for general filter and sorbent tube sample train assembly, as well as proper placement in the employee's breathing zone. For detailed sample pump operation and calibration instructions, refer to your pump's operating manual.

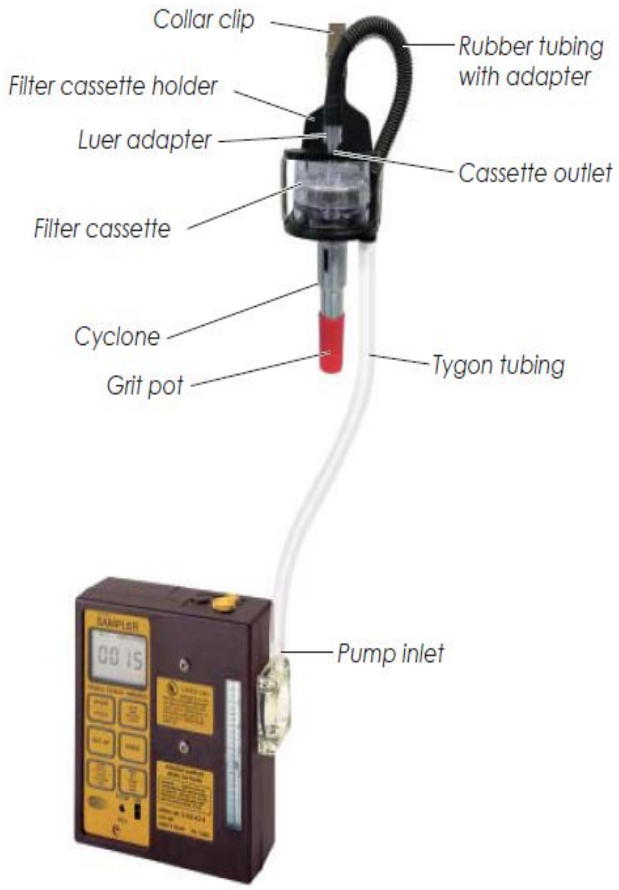
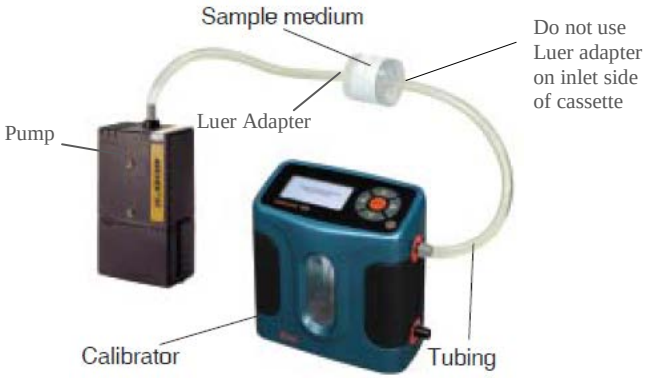
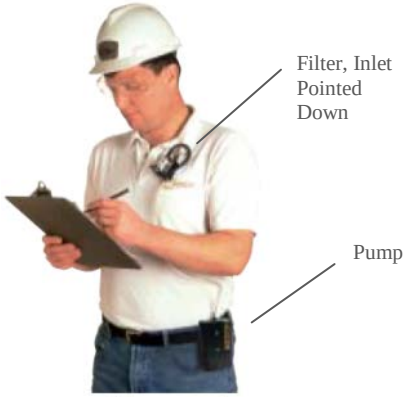
FILTER AND CYCLONE SAMPLE TRAIN ASSEMBLY	
 *Filter and Cyclone Sample Train Assembly*	 *Calibration train with filter cassette*  *Clip sample medium to worker and pump to belt.*

Figure 10. Sample Collection and Calibration Trains for Filters
(Pictures courtesy of SKC, Inc.)

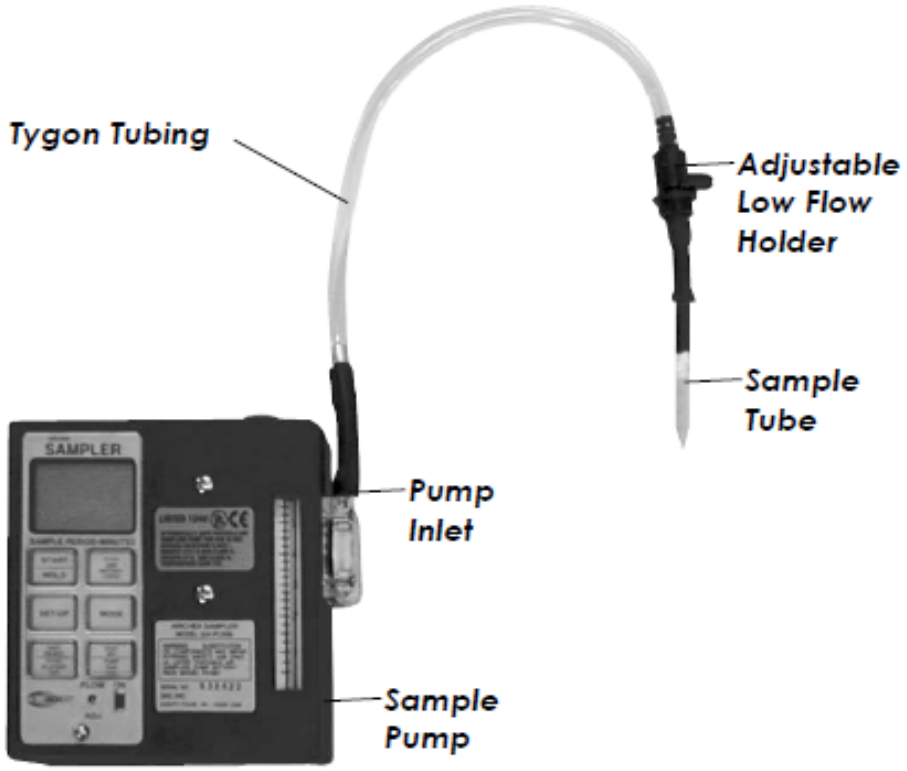
SORBENT TUBE SAMPLE TRAIN ASSEMBLY	
 *Sorbent Tube Sample Train Assembly*	

Figure 11. Sample Collection and Calibration Trains for Sorbent Tubes
(Pictures courtesy of SKC, Inc.)

2.6.1 Sample Pump Calibration. The accuracy of determining the concentration of a toxic substance in air is no greater than the accuracy with which the air volume is measured. Therefore, accurate calibration is necessary before field use (pre-calibration, same day) and after field use (post-use flow rate check, same day).

Both pre- and post-calibration are accomplished using an unused sample media (tube or filter) from the same lot number used for the actual air sampling event. Only one tube or filter needs to be checked, since all media in a given lot number are packed to provide a uniform pressure drop.

If using a nickel-cadmium battery-operated pump, run a fully charged air sampling pump for at least 10 minutes to achieve a normal, stable flow rate prior to calibration. Fully charged nickel-cadmium batteries have an initial high voltage peak, and the 10-minute operating time allows the battery voltage to stabilize. Prior to calibrating or sampling, it is a good idea to allow the pump to equilibrate after moving from one temperature extreme to another.

2.6.2 Flow Rate Reporting. The difference between the pre- and post-calibration flow rates should be equal to or less than 5%. If the difference is greater than 5%, check your pump battery for a valid charge. If the battery is charged and the value is still >5% (0.05), the pump may need to be serviced. If the difference between the flow rates is greater than 5%, the sampling event should be re-accomplished.

DOEHRS uses the lower flow rate (either pre-use or post-use flow) to calculate and report air sample volumes. By using the lower flow rate, the concentration of the analyte(s) reported by the laboratory will conservatively overestimate the airborne concentration in the sampling environment. DOEHRS uses the equation below to determine the flow rate difference; any difference greater than 5% will automatically be flagged in the pre-/post-calibration screen in DOEHRS.

Flow Rate Difference

$$\frac{(\boldsymbol{pre-calibration\ flow\ rate}) - (\boldsymbol{post-calibration\ flow\ rate})}{\boldsymbol{pre-calibration\ flow\ rate}} \times \mathbf{100} \quad (1)$$

Example
You have just completed air sampling and finished your post-use flow check. The pre-use calibration flow was recorded as 3.05 LPM and the post-use flow check was recorded as 2.89 LPM. Determine the flow rate difference for your sampling event.

$$\frac{(3.05\ \text{LPM}) - (2.89\ \text{LPM})}{3.05\ \text{LPM}} \times 100 = 5.25\% > 5\%$$

In this example, since the flow rate difference is >5% the sampling event should be re-accomplished.

2.7 Determining Sample Flow Rate and Volume

2.7.1 Sample Volumes When Concentrations Are at or Near the OEEL. When the sample concentration is estimated to be at or near the OEEL, the flow rate and sample volume can be obtained from the analytical method. When these parameters are used under normal sampling conditions:

- The test result should be accurate for the sample being collected.
- The detection limit for the analytical measurement system (the instrumentation and the method used for testing) can be met.
- The possibility of sample breakthrough is minimized.

With a known flow rate and sample volume, the air sampling time can be calculated using the following equation:

Sample Collection Time

$$\textbf{\textit{Air Sampling Time}}\ (\textbf{\textit{Min}}) = \frac{\textbf{\textit{Volume}}\ (\textbf{\textit{L}})}{\textbf{\textit{Flow Rate}}\ (\textbf{\textit{LPM}})} \quad (2)$$

2.7.2 Deviations from Recommended Volume and Flow Rate. Sampling situations may arise where departures from the recommended sample flow rates and air collection volumes are necessary. When such departures are required, it should be done only when based on an approved sampling plan. Departures from recommended guidance may be necessary under these conditions:

- *High Concentration.* An air collection volume at or near the lower limit of the recommended range should be used in this situation.
- *Dusty Environment.* Filter sampling in dusty areas is required. A lower than recommended total air collection volume should be used when sampling in this environment.
- *Low Level Detection.* The concentration of the analyte in question is expected to be much lower than the OEEL. An air volume at or near the upper limit of the recommended range should be used. For low level detection, the minimum volume needed to obtain an adequate concentration of the desired analyte can be calculated using the reporting limit (RL) and the following formula:

Minimum Air Volume

$$\textbf{\textit{Minimum Air Volume}} = \frac{\textbf{\textit{RL}}}{(\textbf{\textit{OEEL}}) \times (\textbf{\textit{Desired Fraction}})} \quad (3)$$

***Example**:*
*You wish to confirm welders in the NDI shop are not exposed to beryllium above 10% of the AF Action Level (0.0002 mg/m^3) during welding operations. The laboratory RL for beryllium is 0.005 µg, and you intend to sample at 3 LPM. Determine the minimum sample volume and collection time. **Note**: Pay particular attention to your units.*

$$\text{Minium Air Collection Volume (L)} = \frac{(0.005\mu g) \times \left(\frac{1\ mg}{1000\mu g}\right) \times \left(\frac{1000 L}{1\ m^3}\right)}{\left(0.0002 \frac{mg}{m^3}\right) \times \left(\frac{1}{10}\right)} = 250\ L$$

$$\text{Minium Air Sampling Time (min)} = \frac{250\ L}{3\ LPM} = 84\ min$$

2.8 Blanks

There are three main types of blanks, each used for a special purpose. Field and media blank results should be logged into DOEHRS just like a field sample.

- *Media Blanks.* The purpose of media blanks is to check for "pre-existing" presence of the contaminant (media background). These blanks should not be brought into the work environment, and they should never be opened. It is important that these blanks come from the same lot as the field samples. Media blank results with detectable amounts of contaminants may be used to blank correct the field sample results.

- *Field Blanks.* Field blanks should be handled in the same manner as the actual field samples, except no air is drawn through the field blank media. Field blanks must be brought out to the same work environment where the field samples are collected and should be opened and immediately capped. It is important that these blanks come from the same lot as the field samples. Field blanks can help establish if contamination was introduced during sample handling and shipping. Field blank results should NOT be used for blank correction. *Note*: When sending solid sorbent tube field blanks, remember to break the ends of the glass sampling tube and reseal with the plastic caps.

- *Reagent Blanks.* These blanks measure the signal contribution from solvents, acids, or other materials used by the analytical laboratory in preparing the samples for analysis.

  How Many Blanks Should I Submit? The number of blanks will depend on the sampling method and should be annotated on the method documentation. If not annotated, as a general rule, 2 field blanks should be submitted for up to 10 field samples, with a maximum of 10 field blanks for each sample set.

  If media blanks are not specified in the method, you may still submit them to the lab. This is important when a certain media has a history of background contamination, e.g., NIOSH method 7605 using PVC filters. Background Cr(VI) can be found on all commercially available PVC filters as a result of the manufacturing process. Most media blanks analyzed by NIOSH 7605 will have measurable amounts of Cr(VI).

2.9 Blank Corrections

The Chemistry Lab ***does not*** blank correct results when contaminants are detected on media blanks. If contaminant is detected greater than the RL on media blanks, the field sample results should be blank corrected. Remember, only consider media blanks ***not*** field blanks. There are three scenarios to consider:

- All media blanks have reported levels above the RL. Average the reported contaminant mass for all the media blanks. This average will be subtracted from each field sample mass prior to calculating sample results and TWAs.
- None of the media blanks reported levels above the RL. No corrections should be made.
- Some of the media blanks have reported levels above the RL. Average the reported mass for only those media blanks above the RL and correct your field samples.

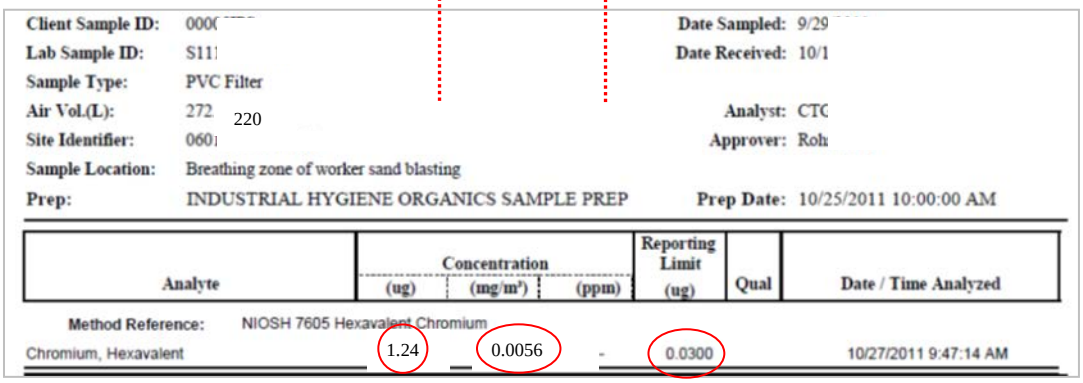
Blank Corrections (4)

$$\textit{Blank Corrected Result}\left(\frac{mg}{m^3}\right) = \frac{[\textit{Field Sample Result}\ (\mu g)] - \textit{avg}[\textit{Media Blank Results}\ (\mu g)]}{\textit{Sample Volume}\ (L)} \times \frac{1000\ L}{1\ m^3} \times \frac{1\ mg}{1000\ \mu g}$$

Example:
You collected Cr(VI) air samples in your structural maintenance shop using NIOSH 7605. You sampled using PVC filters with a collection time of 110 minutes and volume of 220 liters for each filter. The lab's reporting limit is 0.03 µg. Determine the blank corrected sample results given the following information from the lab:

Where do you find the information in the table to the right on a USAFSAM lab report…? See the excerpt from an example lab report below.

Field Sample Results **(µg)**	Field Sample Results **(mg/m^3)**	Media Blank Results **(ug)**
1.24	0.0056	0.65
2.67	0.0121	0.95
1.76	0.0080	-
0.75	0.0034	-



1. Average the media blank results over the RL: $\frac{0.95\ \mu g + 0.65\ \mu g}{2} = 0.8\ \mu g$

2. Subtract the calculated average from each field sample result.

1.24 µg - 0.8 µg = 0.48 µg
2.67 µg - 0.8 µg = 1.87 µg
1.7 6µg - 0.8 µg = 0.96 µg
0.75 µg - 0.8 µg = (-0.05)…< RL of 0.03 µg, default to reporting limit value

3. Use the corrected mass to calculate the sample result.

$$\text{Blank Corrected Sample Result } \left(\frac{\text{mg}}{\text{m}^3}\right) = \frac{1.24\ \mu\text{g} - 0.8\ \mu\text{g}}{220\ \text{L}} \times \frac{1000\ \text{L}}{1\ \text{m}^3} \times \frac{1\ \text{mg}}{1000\ \mu\text{g}} = 0.0022\ \left(\frac{\text{mg}}{\text{m}^3}\right)$$

Corrected Sample Mass (µg)	Sample Volume (L)	Sample Result (mg/m^3)
0.48	220	0.0022
1.87	220	0.0085
0.96	220	0.0044
<0.03	220	<0.0001

2.10 Field Documentation

Each sampling event should be accompanied by detailed documentation including field notes and sampling narratives.

- ***Field Notes.*** Air sampling field notes must include information such as hazardous material, National Stock Number, weapon system, pump start and stop times, pump and calibration equipment model and serial numbers, air temperature, relative humidity, and atmospheric pressure to name a few. This information can be easily documented by clicking and printing the "Generate Blank Sample Report Form" in DOEHRS. Field notes may be documented on the hard copy form and later transcribed in DOEHRS. Refer to Appendix E for additional details on how to print the *Blank Sample Report Form*. Refer to Appendix K for a listing of general observations that should be documented during all air sampling events as wells as observations for specific industrial operations including painting, sanding, and blasting.

- ***Sampling Narratives.*** Sampling narratives should be chronological and provide a written record of industrial activities performed by the employee being sampled. The narrative should be detailed enough to recreate the sampling event and to ensure information can be validated during subsequent data reviews. In addition to narrative comments, actual photos are a great complement to written observations. Sampling narratives are important, since sample results will reflect worker habits, movements, and behavior in relation to the source(s) of contamination. Refer to Appendix K for an example sampling narrative.

2.11 TWA Calculations

To properly calculate an employee's TWA exposure, professional judgment is necessary to decide what assumptions should be made regarding the exposure during unsampled work periods. For example, if the work shift is 8 hours and sampling was conducted for 7 hours and 15 minutes, you can either assume a zero exposure for the unsampled period or assume the exposure is equal to the TWA over the sampled period. TWAs are calculated using the following equations:

TWA Calculations

$$TWA_{8h} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{480\ min}$$ ← 8-h TWA calculations when the employee exposure during the unsampled portion of the shift is assumed to be zero. (5)

$$TWA_{15\ min} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{15\ min}$$ ← 15-min TWA-STEL calculations when the employee exposure during the unsampled portion of the operation is assumed to be zero. (6)

$$TWA = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{T_1 + T_2 + \ldots + T_n}$$ ← 8-h TWA or 15-min STEL calculations when the employee exposure during the unsampled portion of the shift is assumed to be equal to the average exposure of all sampled portions of the shift. (7)

***Example**:*
You would like to calculate the 8-hour TWA for your structural maintenance personnel from the example presented in 2.9. You have determined the employee's exposure during the unsampled portion (lunch) of the work shift to be equal to zero. Given the information below, calculate the 8-hour TWA.

Sample Result (mg/m^3)	Collection Time (min)
0.0022	110
0.0085	110
0.0044	110
<0.0001	110

$$TWA_{8h} = \frac{(0.0022\ mg/m^3)(110\ min) + (0.0085\ mg/m^3)(110\ min) + (0.0044\ mg/m^3)(110\ min) + (0.0001 mg/m^3)(110\ min)}{480\ min}$$

$$TWA_{8h} = 0.0035\ mg/m^3$$

2.12 Sampling and Analytical Error

Sampling and analytical error (SAE) is a term used to account for the total error of a method and is used by OSHA in compliance sampling. The SAE is a summation of the sampling, analytical, and pump errors. The SAE does not account for varying concentration levels that may occur due to workplace variables. OSHA refers to these errors as the total coefficient of variation (CV_T). NIOSH does not use the term CV_T but rather overall precision (S_{rT}). When calculating SAEs, the OSHA CV_T and NIOSH S_{rT} are equivalent. For a precise estimation of error, the S_{rT} or CV_T value should be obtained from the laboratory that performed the analysis. ***Note:*** If the lab does not deviate from the published method, the estimated S_{rT} found on the first page of most NIOSH methods under the accuracy section may be used. The laboratory, upon request, will provide the measurement uncertainty and the bias for methods that have been modified or do not have a published S_{rT}.

OSHA and NIOSH Sampling and Analytical Error

95% Confidence Interval

OSHA Methods		***NIOSH Methods***
$\mathbf{SAE = CV_T \times 1.645}$	$\longrightarrow$ *Since* $CV_T = S_{rT}$... $\longrightarrow$	$\mathbf{SAE = S_{rT} \times 1.645}$

(8,9)

Where:
SAE = sampling and analytical error
CV_T = total coefficient of variation (OSHA)
S_{rT} = overall precision (NIOSH)
1.645 = statistical constant

Example*:*
You would like to calculate the SAE for the Cr(VI) samples collected in example 2.9. Your samples were analyzed by the Chemistry Lab using NIOSH 7605 [Cr(VI)].

Start by referencing your final report from the lab and note the analytical method. If the lab deviates from the published method, it will be annotated in the report. The Chemistry Lab does not modify NIOSH 7605; therefore, the S_{rT} value listed on the first page of the NIOSH method can be used to calculate the SAE. Referencing NMAM 7605, you notice the S_{rT} equals 0.07:

Hexavalent Chromium Sampling Event → SAE = 0.07 X 1.645 = 0.12

Upon request, the laboratory shall provide the measurement uncertainty (U) and the bias (B) when the laboratory deviates from the published method or when no S_{rT} value is published. After requesting the U and B from the Chemistry Lab, these values can be used along with the air sampling pump's coefficient of variation (CV_P) to determine the SAE. The CV_P should be obtained from the manufacturer's specifications; if unknown, an estimate of 0.05 can be used. Contact Customer Service for additional information regarding the uncertainty and bias for a specific method. ***Note:*** Equation 11 below applies specifically for samples analyzed by the USAFSAM/OEA Chemistry Lab. The analytical coefficient of variation (CV_A) should be obtained by calling Customer Service for samples analyzed by commercial labs.

SAE Using Laboratory Method Uncertainty

$$\boldsymbol{SAE = \sqrt{(CV_A)^2 + (CV_P)^2}\ X\ 1.645} \quad (10)$$

$$\mathbf{CV_A = \frac{\frac{U}{2}}{100+B}} \quad (11)$$

Where:
CV_P = pump coefficient of variation, if unknown use 0.05
CV_A= analytical coefficient of variation
U = measurement uncertainty (reported by lab)
B = method bias (reported by lab)

Example
You have just completed lead sampling following NIOSH 7300. You refer to the final report and notice the reference method shows "NIOSH 7300 MOD," indicating the lab has used a modified method from the NIOSH publication. Determine the SAE associated with this sampling event.

In this scenario, the lab can provide the measurement uncertainty and bias. After requesting U and B, an amended report is issued with the following comments in the narrative:

"The following method uncertainties apply only to the items tested for the workorder and cannot be applied to other data. The laboratory method uncertainty associated with Pb at ~95% confidence level is ± 10.8% with a bias of -0.6% (k=2, n=233). SDD 06 Jan 11."

The air sampling pump manufacturer lists the coefficient of variation as 4.0%. Calculate the SAE for the sampling event:

$$CV_A = \frac{\frac{10.8}{2}}{100+(-0.6)} = 0.054 \qquad CV_P = 0.04$$

$$SAE = \sqrt{(0.054)^2 + (0.04)^2} \text{ X } 1.645 = 0.111, \text{ or } \pm 11.1\%$$

2.13 Upper and Lower Confidence Limits

When an employee is sampled and the TWA is calculated, this measured exposure average will rarely be exactly the same as the true average exposure. The discrepancy between the measured and true exposure is a result of random sampling errors and environmental fluctuations within a work shift. Thus, the result of the sampling is referred to as an average exposure estimate (or estimate of the true average exposure). Statistical methods allow us to calculate interval limits for each side of the average exposure estimate that will contain the true exposure average at a selected confidence level. The numerically larger limit is known as the upper confidence limit (UCL), and the numerically smaller limit is known as the lower confidence limit (LCL). Figure 12 illustrates the one-sided LCL and UCL for an average exposure estimate.

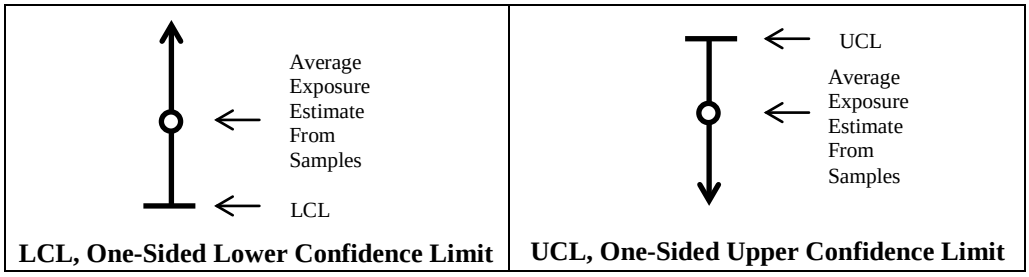


Figure 12. Example of One-Sided LCL and UCL
[Adapted from Figure 4.1 in the NIOSH Occupational Exposure Sampling Strategy Manual (Jan 1977)]

Sampling and analytical errors shall be incorporated into sample results to obtain the LCL and also the UCL (both with a degree of statistical confidence). These terms are often applied with a 95% statistical confidence limit and expressed as $LCL_{95\%}$ and $UCL_{95\%}$. The $LCL_{95\%}$ and $UCL_{95\%}$ are calculated differently depending upon the type of sampling method used, but all calculations start with determining the exposure severity (Y).

One-sided confidence limits (LCL or UCL) can be used to classify average exposure into one of three possible exposure categories. The use of the LCL (by a compliance officer) would result in a decision of either noncompliance exposure or possible overexposure. The use of the UCL (by the employee) would result in a decision of either compliance exposure or possible overexposure. Figure 13 depicts the three classification categories summarized in Table 12.

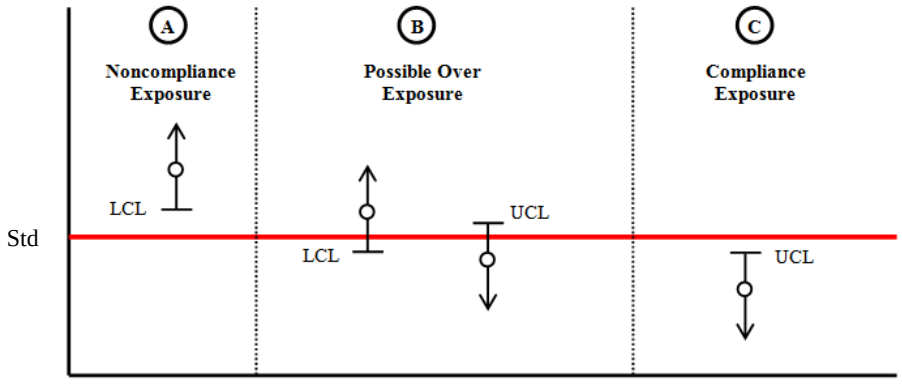


Figure 13. Classification According to One-Sided Confidence Limits
[Adapted from Figure 4.2 in the NIOSH Occupational Exposure Sampling Strategy Manual (Jan 1977)]

Table 12. Classification System for Employee Exposure to Contaminants[a]

Classification	Definition	Statistical Criterion	Recommendation
A. Noncompliance Exposure	There is 95% confidence (based on measurements) that a worker's exposure is above the standard	$LCL_{95\%} > 1$	Implement control measures
B. Possible Overexposure	Any individual who cannot be classified in A or C	$LCL_{95\%} < 1$ $UCL_{95\%} > 1$	Further characterization required
C. Compliance Exposure	There is 95% confidence (based on measurements) that a worker's exposure is below the standard	$UCL_{95\%} < 1$	Perform periodic reassessment

[a]Adapted from Table 4.1 in the NIOSH Occupational Exposure Sampling Strategy Manual (Jan 1977)

$LCL_{95\%}$ and $UCL_{95\%}$

$$Y = \frac{X}{OEEL}$$ (12)

Exposure Severity
X is the full-period sampling result , and Y is the exposure severity.

$$LCL_{95\%} = Y - SAE$$
$$UCL_{95\%} = Y + SAE$$ (13)

Full-Period, Continuous Single Sample
X is the full-period sampling result, and Y is the exposure severity.

$$LCL_{95\%} = Y - \frac{SAE\sqrt{(T_1X_1)^2 + (T_2X_2)^2 + \cdots + (T_nX_n)^2}}{PEL\,(T_1 + T_2 + \cdots + T_n)^2}$$
$$UCL_{95\%} = Y + \frac{SAE\sqrt{(T_1X_1)^2 + (T_2X_2)^2 + \cdots + (T_nX_n)^2}}{PEL\,(T_1 + T_2 + \cdots + T_n)^2}$$ (14)

Full-Period, Consecutive Sampling
$X_1, X_2, \ldots X_n$ is the n consecutive concentrations in a work shift and their corresponding time durations are $T_1, T_2, \ldots T_n$.

Example

Referring to the example in 2.11 and 2.12, determine if the Cr(VI) exposure is a noncompliance exposure, possible overexposure, or a compliance exposure. The applicable OEEL is 0.005 mg/m^3. The SAE was previously determined to be 0.12.

Recall from earlier the consecutive concentrations, corresponding time durations, and resulting TWAs:

Sample Result (mg/m^3)	Collection Time (min)	TWA (mg/m^3)
0.0022	110	0.0035 mg/m^3
0.0085	110	
0.0044	110	
<0.0001	110	

Since the TWA result is less than the OEEL (0.0035 mg/m^3 < 0.005 mg/m^3), next calculate the UCL:

$$UCL_{95\%} = \frac{0.0035\ \text{mg/m}^3}{0.005\ \text{mg/m}^3} + \frac{0.12\sqrt{(110 \times 0.0022)^2 + (110 \times 0.0085)^2 + (110 \times 0.0044)^2 + (110 \times 0.0001)^2}}{0.005\ \text{mg/m}^3\,(110 + 110 + 110 + 110)^2} = 0.70$$

The $UCL_{95\%}$ (0.70) < 1, so you are 95% confident the exposure is less than the OEEL and classified as a compliance exposure.

2.14 Temperature and Pressure Corrections

Air volume is directly affected by temperature (T) and pressure (P), and corrections must be made when calibration and sampling are conducted at two different locations with substantially different T and P conditions. To prevent the required use of a correction factor, the sampling pump should be calibrated in the field. If calibration in the field is not possible, then the indicated flow rate at the time of sampling must be corrected using Equation 15 below. The equation below should only be used for rotameter sampling pumps (the most popular field instrument used for air sampling).

In general, temperature and pressure corrections should only be used when a significant shift has occurred between the calibration and field conditions. According to both NIOSH and OSHA, a deviation of more than ±5% of the calibration value is considered to be a significant shift. In

other words, a flow rate should be corrected if measured conditions exceed calibration conditions by 5% or greater using Equation 15 below. ***Note:*** Most newer air sampling pumps ***automatically*** correct for variations in temperature and pressure to deliver a constant flow rate. Refer to the manufacturer's literature to determine if your pump has this capability. If this is the case, Equation 15 is not necessary.

Flow Corrections for Temperature and Pressure

$$Q_{Field} = Q_{Cal}\sqrt{\frac{P_{cal}}{P_{Field}} \times \frac{T_{Field}}{T_{cal}}} \quad (15)$$

Where:

Q_{Field} = flow rate at field sample conditions (LPM)
Q_{Cal} = flow rate Indicated during calibration (LPM)
P_{cal} = pressure during calibration (torr)
T_{cal} = temperature during calibration (__°C+273)
P_{Field} = pressure at field sampling location (torr)
T_{Field} = temperature at field sampling location (_°C+273)

Example*:*
Your air sampling pump was calibrated to 2.0 LPM in Cincinnati, OH, at an elevation of 575 feet (744 torr) and a temperature of 24 °C. The pump was then used to obtain a 2-hour sample at an elevation of 6000 feet (605 torr) with a temperature of 10 °C. What sample volume should you report to the laboratory?

Determine the actual flow rate at the time of sampling using Equation 6:

$$Q_{Field} = 2.0 \text{ LPM}\sqrt{\frac{744 \text{ torr}}{605 \text{ torr}} \times \frac{10°C+273}{24°C+273}} = 2.17 \text{ LPM}$$

$$\text{Reported Volume} = 2.17 \text{ L/min} \times 60 \text{ min/h} \times 2 \text{ h} = 259.8 \text{ L}$$

2.15 Application of OEELs To Unusual Ambient Conditions

The objective of industrial hygiene air sampling is to obtain the best estimate of the employee exposure to an airborne concentration in the workplace. Analytical laboratories generally report the *mass* of the contaminant found on a filter or charcoal tube. The lab uses the customer-provided sample volume to calculate the airborne concentration at the sampling site. Care should be taken in comparing the lab result to applicable OEELs when site temperature and pressure are substantially different than those at normal temperature and pressure (NTP) conditions (25 °C and 760 torr). Refer to the following guidelines below when comparing sampling results obtained under unusual atmospheric conditions to OEELs:

- *Aerosols*. For aerosols, compare the mass per unit of actual volume (not adjusted to NTP) to the OEEL. Volumes reported to the lab should be the air sample volume collected at site temperature and pressure without adjustment. Since most aerosol OEELs are published in terms of mass of the chemical substance in air by volume (mg/m^3), the units reported by the lab (also mg/m^3) will match those in published OEELs. No conversions are necessary.
- *Gases and Vapors*. For gases and vapors, most OEELs are established in terms of parts of vapor or gas per million parts of contaminated air by volume (ppm). As

mentioned earlier, most analytical laboratories generally report results in mg/m^3. To compare gas and vapor results to the OEEL, follow the procedures defined by ACGIH® and outlined below:

Step 1. Determine the exposure concentration, expressed in terms of mass per volume, at the sampling site using the sampling volume not adjusted to NTP conditions.

Step 2. If required, convert the OEEL to mg/m^3 (or other mass per volume measure) using a molar volume of 24.45 L/mole and Equation 16 below, where 24.45 equals the molar volume of air in liters at NTP conditions. The molecular weight of various contaminants of concern can be obtained from the NIOSH Pocket Guide to Chemical Hazards.

Step 3. Compare the exposure concentration to the OEEL, both in units of mass per volume.

Unit Conversions

$$mg/m^3 = (ppm) \times \frac{Molecular\ Weight\ of\ Contaminant\ of\ Concern}{24.45} \quad (16)$$

Example:
Personal air sampling was performed on workers exposed to benzene in Salt Lake City, UT (ambient air temperature = 33 °C, measure barometric pressure = 670 torr). The sample flow rate is 0.050 LPM for a duration of 126 minutes. The analytical laboratory reports a collected sample mass of 6.33 µg (0.00633 mg). You wish to compare the results to the TLV®-TWA of 100 ppm. The molecular weight of benzene is 88.15 AMU.

Example Sample Results:

Client Sample ID:		**Date Sampled:**	
Lab Sample ID:		**Date Received:**	
Sample Type:	Charcoal CB		
Air Vol.(L):	6.3	**Analyst:**	
Site Identifier:		**Approver:**	
Sample Location:			
Prep:	IH SamplePrep	**Prep Date:**	

Analyte	Concentration (ug)	Concentration (mg/m³)	Concentration (ppm)	Reporting Limit (ug)	Qual	DF	Date / Time Analyzed
Method Reference: NIOSH 1501							
Benzene	6.33	1.01	--	5.49		1	12/21/2011 10:56:05 AM
Toluene	63.9	10.1	--	5.42		1	12/21/2011 10:56:05 AM
Xylenes, Total	262	41.6	--	10.8		1	12/21/2011 10:56:05 AM
Method Reference: NIOSH 1550							
JP- 8 Jet Fuel	5540	879	--	122		3	12/22/2011 4:15:55 PM

Step 1. Calculate the sample volume collected at the sampling site (note that the sample volume is not adjusted to NTP conditions). Then calculate the TWA exposure concentration measured at the sampling site:

a.) Sample Volume = $0.050 \text{ LPM} \times 126 \text{ min} = 6.3 \text{ L}$ *or*

$$= 0.050 \text{ LPM} \times 126 \text{ min} \times \frac{\text{m}^3}{10^3 \text{ L}} = 0.00625 \text{ m}^3$$

b.) Sample Concentration = $\frac{0.00633 \text{ mg}}{0.00625 \text{ m}^3} = 1.01 \text{ mg/m}^3$

c.) 8-h TWA = $\frac{(1.01 \text{ mg/m}^3) \times (126 \text{ min})}{480 \text{ min}} = 350 \text{ mg/m}^3$

Step 2. Convert the TLV® ppm concentration to a mg/m^3 concentration using Equation 5:

$$\text{mg/m}^3 = (100 \text{ ppm}) \times \frac{88.15}{24.45} = 360 \text{ mg/m}^3$$

Step 3. Directly compare the TWA exposure concentration to the TLV®-TWA:

Sampling Site TWA Exposure Concentration	**ACGIH® TLV®-TWA Concentration**
350 mg/m^3	**360 mg/m^3**

2.16 Chemical Mixtures

Chemical mixtures can have three different effects: additive, independent, or synergistic.

- *Additive Effects.* Additive effects may be combined by summing the exposure severity when chemicals in a mixture have the same target organ. If the exposure severity of the mixture ($Y_{mixture}$) is greater than one, the exposure is considered to exceed the OEEL for the mixture.
- *Independent Effects.* If the chemical substances in the mixture have different biological actions, the data must not be combined into a single exposure value. Instead, the concentration of each chemical substance must be separately compared to its OEEL.
- *Synergistic Effects.* If the chemical substances in the mixture have synergistic effects, interpretation of the data should be done on a case-by-case basis and with great caution.

Equivalent Exposure Severity for a Mixture

$$Y_{mixture} = \frac{C_1}{OEEL_1} + \frac{C_2}{OEEL_2} + \cdots + \frac{C_n}{OEEL_n} \quad (17)$$

Example:
You would like to calculate the exposure to three different but additive substances:

Material	***8-h Exposure***	***8-h TWA OEEL***
Substance 1	500	1000
Substance 2	80	200
Substance 3	70	200

$$Y_{mixture} = \frac{500}{1000} + \frac{80}{200} + \frac{70}{200} = 1.25$$

Since $Y_{mixture} > 1$, the OEEL for the mixture has been exceeded.

2.17 Nontraditional Work Schedules

Standards based on 8-hour exposures may not provide appropriate protection when nontraditional work schedules are used, e.g., four 10-hour days per week. Comparison of the full-shift exposure measured during a nontraditional work schedule requires adjustment of the 8-hour OEEL to account for differences in the number of exposure (i.e., work) hours and recovery (i.e., nonwork) hours. Reduced down time means less time for the body to eliminate chemicals, resulting in increased body burden. The goal is to ensure that workers with unusual shifts do not exceed the same threshold body burden resulting in health effects.

The two most well-known methods for exposure limit adjustment are the OSHA model and Brief and Scala model. Choosing to adjust an exposure limit and selecting a method should be based on the chemical's biological half-life and the severity of health effects. Short-term exposure limits; ceiling standards; and exposure limits for irritants, simple asphyxiants, and chemicals with a biological half-life of less than 3 hours are not typically adjusted. In general, substances with acute effects should be adjusted if the shift exceeds 8 hours; substances with chronic effects should be adjusted if the week exceeds 40 hours. Adjusted OEELs may be selected in DOEHRS when determining employee TWAs.

2.17.1 OSHA Compliance and Extended Work Shifts. The lead standards for construction and general industry require PEL adjustments with respect to extended work shifts when determining compliance. To reduce employee level of exposure, the occupational exposure to the cotton dust standard also has a requirement to adjust extended work shifts when employees are required to wear respirators for a portion of the work shift. With these two exceptions, there is *no* additional regulatory requirement to adjust PELs for extended work shifts. Historical versions of the OSHA Field Inspection Reference Manual included the *OSHA Model* for adjusting PELs for extended work shifts. This model categorized air contaminants into one of six categories based on their toxic effects. Depending on the type of toxic effect, an appropriate adjustment procedure was selected and applied to the exposure limit. This model has been removed from the current OSHA Field Operations Manual, and while still an available option in DOEHRS, this method is not recommended.

2.17.2 Brief and Scala Model. The Brief and Scala model is the preferred model for calculating adjustments of 8-hour TWA exposure standards. This model is a conservative approach to adjusting OEELs for unusual work shifts, incorporating increased work shift exposures and decreased recovery time. The following assumptions apply when using the Brief and Scala method:

- The model does not account for biological half-lives of the stressor, as do pharmacokinetic models. As a general rule, OEEL adjustments using this model should not be applied if the chemical half-life is less than 3 hours or greater than 400 hours. Studies show that only moderate half-life chemicals (i.e., 6-200 hours) are likely to have day-to-day accumulation during the week, even for exposures at or near the OEEL.
- The model assumes average body burden for the chemical rather than peak burden.
- The model can be used if the OEEL is based on systemic effects, regardless of whether the effects are acute or chronic.
- Adjustments can be applied only for extended work shifts/weeks, defined as >7 hours/day or >35 hours/week. Do not use these equations for shortened work schedule adjustments (i.e.,

the OEEL should NEVER be adjusted for shortened workdays or weeks). Additionally, neither adjustment equation is appropriate for 24-hour (i.e., continuous) exposure.

- Do not make OEEL adjustments when the chemical is a primary irritant (i.e., PEL based on sensory irritation effects). In such cases, the chemical's action is based on "compartmental" vice whole body effects. Furthermore, the irritation threshold is probably independent of the number of hours worked.

The adjusted OEEL is then used for comparison with the employee's TWA exposure and its upper or lower confidence limits as appropriate.

Brief and Scala Model

Work Week Less Than 7 Days

$$\textit{Adjusted OEEL} = OEEL \times \left(\frac{8}{h} \times \frac{24-h}{16}\right)$$

Where:
h = number of hours worked per day
8 = number of hours per traditional workday
24 = number of hours per day
16 = number of recovery hours per traditional workday

7-Day Work Weeks (18,19)

$$\textit{Adjusted OEEL} = OEEL \times \left(\frac{40}{h} \times \frac{168-h}{128}\right)$$

Where:
h = number of work hours per 7-day week
40 = number of work hours per traditional work week
168 = number of hours per 7-day work week (7 days x 24 h)
128 = number of recovery hours per traditional work week

***Example**:*
The Allied Trades employees at your installation work four consecutive 12-hour shifts with 3 days off. Workers perform sanding operations on Cr(VI). The applicable OEEL is the ACGIH® TLV® of 0.005 mg/m³. Using the Brief and Scala method, determine the adjusted OEEL.

$$\text{Adjusted OEEL} = 0.005\ \text{mg/m}^3 \times \left(\frac{8}{12} \times \frac{24-12}{16}\right) = 0.0025\ \text{mg/m}^3$$

2.18 Conversion of Sample Results from an Element to a Compound

In a metal scan, metals [e.g., iron (Fe), zinc (Zn), and vanadium (V)] concentrations are reported in their elemental form as mg/m³ instead of the metal oxide concentrations (e.g., Fe_2O_3, ZnO, and V_2O_5). To convert a sample result from an element to a compound containing that element, the equation below can be used. The equation assumes the only source of the elemental metals is from the metal oxide.

Conversion of Sample Results from Element to a Compound

$$RC = RR \times \frac{MWC}{MWE} \quad (20)$$

Where:
RC = result for compound (mg/m³)
RR = reported result for element (mg/m³)
MWC = molecular weight of desired compound
MWE = molecular weight of reported element

***Example**:*
Your results from the lab reported sodium (Na) as 100 mg/m^3. The only source of sodium during your sampling event was sodium hydroxide (NaOH). You wish to determine the NaOH concentration. [Note: molecular weight (MW) of Na is 23; MW of NaOH is Na(23) + O(16) + H(1)]

$$\text{RC} = 100\,\text{mg/m}^3\,\text{Na} \times \frac{40\ (\text{MW of NaOH})}{23\ (\text{MW of NA})} = 173.9\ \text{mg/m}^3$$

Other $\frac{\text{MWC}}{\text{MWE}}$ examples include:

Zinc Oxide: $\frac{\text{MW of ZnO}}{\text{MW of Zn}} = \frac{81.4}{65.4} = 1.245$

Vanadium Pentoxide: $\frac{\text{MW of } V_2O_5}{\text{MW of } V_2} = \frac{181.9}{101.9} = 1.785$

Iron Oxide: $\frac{\text{MW of } Fe_2O_3}{\text{MW of } Fe_2} = \frac{159.7}{111.7} = 1.43$

2.19 Statistics… Going Beyond UCL and LCL

To calculate statistics in DOEHRS, the software requires at least six samples. This supports AIHA's recommendation that six or more measurements should be collected to characterize an exposure profile as a minimum. For many processes with moderate to high variability, fewer than six measurements usually leaves a great deal of uncertainty about the exposure profile. For detailed discussions on statistics and exposure profiles, refer to AIHA's *A Strategy for Assessing and Managing Occupational Exposures* or the USAFSAM IH Stats Web Seminar. Statistical tools are powerful only if their theoretical bases and limitations are understood by the person using them. There is no one ideal statistical technique for evaluating industrial hygiene monitoring data – all have advantages and disadvantages. A few tips to consider include:

- Decide on an exposure metric for comparison with the exposure limit. As discussed earlier, a common metric used is the 95th UCL. Also the 95th percentile (not the 95th UCL) is being used in Bayesian statistical programs such as IHSTAT (see below). In addition to the UCL, refer to Appendix E for a list of descriptive and inferential statistics available in DOEHRS that may aid in summarizing data. Remember that at least six samples are required to perform a quantitative statistical analysis in DOEHRS.
- Take note of the geometric standard deviation, which shows the degree of variability in the data set. The geometric standard deviation allows one to rank the variability between data sets.
- Decide on how to handle censored (i.e., nondetect) data. Novice statistical users use the laboratory reporting limit as the value or substitute half the reporting limit. Advanced statistical users commonly use the maximum likelihood estimation method to reduce bias in the results.
- The Exposure Assessment Strategies Committee of AIHA has a free Excel spreadsheet, IHSTAT, on industrial hygiene statistics on its website. If required, this spreadsheet may be used to perform statistical analyses on data sets of fewer than six samples.

2.20 Fiber Counts and Asbestos Identification

There are several types of analyses that may be used for counting and identifying asbestos, shown in Table 13, including the following:

Bulk, Polarized Light Microscopy (PLM). PLM with dispersion staining is used to analyze bulk samples. PLM is usually very specific, but some nonasbestiform silicate amphiboles, such as fibrous tremolite, can compromise its specificity. PLM analysis reports an asbestos percentile range due to the subjective and inaccurate nature of the estimation.

Air Phased Contrast Microscopy (PCM). PCM is the most common method of analysis for airborne asbestos samples. PCM is relatively accurate due to its dimensional counting rules and optical resolution limitations. Fibers will be counted as asbestos if their length-to-width ratio is 3 to 1 and the fibers are longer than 5 µm. Because some fibers may fall within the asbestos fiber parameters and be considered "OSHA Fibrous," nonasbestos fibers will be counted as asbestos.

Air Electron Microscopy. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) are two electron microscopy techniques commonly used for asbestos analysis. Major advantages include the ability to count smaller fibers than PCM and to identify the type of fiber. Major disadvantages are high costs (10-20 times PCM), tedious analysis, and lengthy turnaround time. The asbestos exposure standard was developed with PCM data; hence, there is no relevant standard to compare the TEM or SEM results, and SEM has no accepted standard method.

Air Sampling. Highlights of the PCM method, NIOSH 7400, are below:

- Use a 25-mm cassette for all breathing zone exposure monitoring.
- An MCE filter membrane with a pore size of 0.8 µm or 1.25 µm must be used. We recommend ordering and using only 0.8-µm filters that have been factory prescreened for background fibers.
- The sampling flow rate must be between 0.5 and 2.5 LPM. Use 2.5 LPM for standardization unless circumstances deem otherwise. For monitoring area concentrations, use between 1 and 16 LPM. If high flow area sampling is performed, use 12 LPM for standardization.
- Do all asbestos sampling open face. The 25-mm cassette must have a 50-mm extension cowl that is electrically conductive.
- During sampling, static charges can accumulate on the cassette cowl that will reduce the sample's fiber concentration efficiency. Ideally, the complete cassette body should be the black conductive type and grounded by wire to some metal fixture (e.g., plumbing, railing, electrical outlet, etc.). Realistically, grounding a breathing zone sample is impractical, but it still helps to use a conductive cowl with a black conductive filter base connected to conductive tubing. The black stripe in clear plastic tubing is graphite, which makes the tubing conductive. It is particularly important to ground high-volume, long-duration samples, which have the greatest potential for building up static charges. Area sampling with an alternating current voltage high-flow pump that has a grounded plug makes it easy to ground the cassette cowl to the pump's frame.

Sample Shipments. Do not ship sampled cassettes in packing that has high electrostatic charges on its surfaces because it can cause fiber migration from the filter to the cassette walls during shipment. Don't use polystyrene "peanuts"; use only crushed or shredded paper or plastic "blister" sheeting.

Table 13. Asbestos Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 7400 ***A Rules***	0.8-µm MCE, 25-mm, conductive cowl on cassette	Primarily used for estimating asbestos concentrations, but does not differentiate between asbestos and other fibers. Use in conjunction with NIOSH 7402 for assistance in identification of fibers.
Air	NIOSH 7400 ***B Rules***	0.8-µm MCE, 25-mm, conductive cowl on cassette	B counting rules are more appropriate for measurement of specific nonasbestos fiber types, such as fibrous glass, refractory ceramic fibers, and carbon fibers. The upper diameter limit in this method prevents measurements of nonthoracic fibers.
Air	NIOSH 7402	0.8-µm MCE, 25-mm, conductive cowl on cassette	Used to determine asbestos fibers in the optically visible range and is intended to complement the results obtained by PCM (NIOSH 7400).
Bulk	EPA 600/R-93/116	Wide mouth glass jar	Should only be used in conjunction with a health risk assessment.
Settled Dust (Wipe Sample)	ASTM D6480-99	Ghost Wipe	Should only be used in conjunction with a health risk assessment.

2.21 Composite Materials

During aircraft maintenance and crash and recovery operations, workers may be exposed to fibrous and nonfibrous composite particulates. For composite materials, the recommended methods are shown in Table 14.

Table 14. Composite Material Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 7400 B Rules	0.8-µm MCE, 25-mm, conductive cowl on cassette	B counting rules are more appropriate for measurement of specific nonasbestos fiber types, such as fibrous glass, refractory ceramic fibers, and carbon fibers. The upper diameter limit in this method prevents measurements of nonthoracic fibers. Ensure the samples are clearly marked "for fibers other than asbestos" and specify the type of fiber if known.
Air	NIOSH 0500	Preweighed, 5-µm PVC, 37- mm cassette	NIOSH 0500 is recommended to determine total particulates not otherwise regulated. Preweighed PVC filters ordered from the manufacturer are the recommended media. Matched-weight media may also be used if preweighed media is not available.
Air	NIOSH 0600	Preweighed, 5-µm PVC, 37-mm cassette with cyclone	NIOSH 0600 is recommended to determine respirable particulates not otherwise regulated. Preweighed PVC filters ordered from the manufacturer are the recommended media. Matched-weight media may also be used if preweighed media is not available.

2.22 Respirable, Thoracic, Inhalable, and "Total" Particulates

Particulate samples may represent the respirable, thoracic, or inhalable fractions of the particulates or the nominal "total" particulates. Each particulate fraction requires a different sampling device. Care should be taken when determining which particulate fraction an OEEL refers to and ensure that the correct sampling method and device are used (Table 15).

Table 15. Respirable and Total Particle Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 0500 (Total)	5.0-µm, 37-mm preweighed PVC filter, *or* 0.8-µm, 37-mm matched-weight MCE filter, *or* 5.0-µm, 37-mm matched-weight PVC filter	Lab is unable to analyze samples collected on media other than matched-weight or preweighed filters. Preweighed PVC filters are the preferred media.
Air	NIOSH 0600 (Respirable)	5.0-µm, 37-mm preweighed PVC filter, *or* 0.8-µm, 37-mm matched-weight MCE filter, *or* 5.0-µm, 37-mm matched-weight PVC filter *and* Cyclone (10-mm nylon cyclone or aluminum cyclone)	Preweighed PVC filters are the preferred media. See manufacturer's guidance for calibration of cyclone assembly. Cyclone should be inspected prior to use. If cyclone is visibly scored, do not use. Refer to manufacturer's literature for proper sampling flow rates. Do not invert the sampler assembly at any time; this may deposit oversized material from the cyclone body onto the filter. Cyclones should be removed prior to sending cassettes to the lab.

Respirable Particulates. Respirable particulates penetrate to the pulmonary region containing the respiratory bronchioles, alveolar ducts, and alveolar sacs (gas exchange) and generally are considered to be 5 µm or less in aerodynamic diameter. Respirable dust is collected using a clean cyclone (Figure 14) at a flow rate recommended by the manufacturer to achieve the predetermined collection efficiencies. Sampling is usually done with a cyclone upstream of the filter to preselect the fraction of particles of each size that pass through the cyclone and are collected on the filter. Several types of cyclones are available, including the 10-mm nylon cyclone and the aluminum cyclone. The flow rate is critical to obtaining the correct aerosol distribution. The manufacturer should be consulted for the recommended flow rate to conform to the respirable aerosol size distribution. When sampling with a cyclone, remember the following tips:

- Prior to using a cyclone, remove the grit cap and vortex finder and inspect the cyclone interior. If the inside is visibly scored, discard the cyclone, since the dust separation characteristics of the cyclone might be altered.
- Following the manufacturer's recommendations, clean the interior of the cyclone to prevent re-entrainment of large particles. Clean all parts of the cyclone, including the interior of the grit pot, with mild soapy water. The cyclone can be wiped with a clean dust-free tissue, air dried, blow dried, or wiped with isopropyl alcohol.
- Sampling trains using cyclones require the use of a 1-liter "calibration jar"; refer to the manufacturer's recommendations for detailed calibration instructions.

- When sampling for the respirable fraction of particulates, the cyclone should not be inverted when attached to the filter cassette. Larger particles are collected in the grit chamber during sampling; inverting the cyclone can cause the larger particles to fall out of the grit chamber and onto the filter, resulting in erroneously high results.
- Cyclones must be removed from filter cassettes prior to sending the samples to the lab.

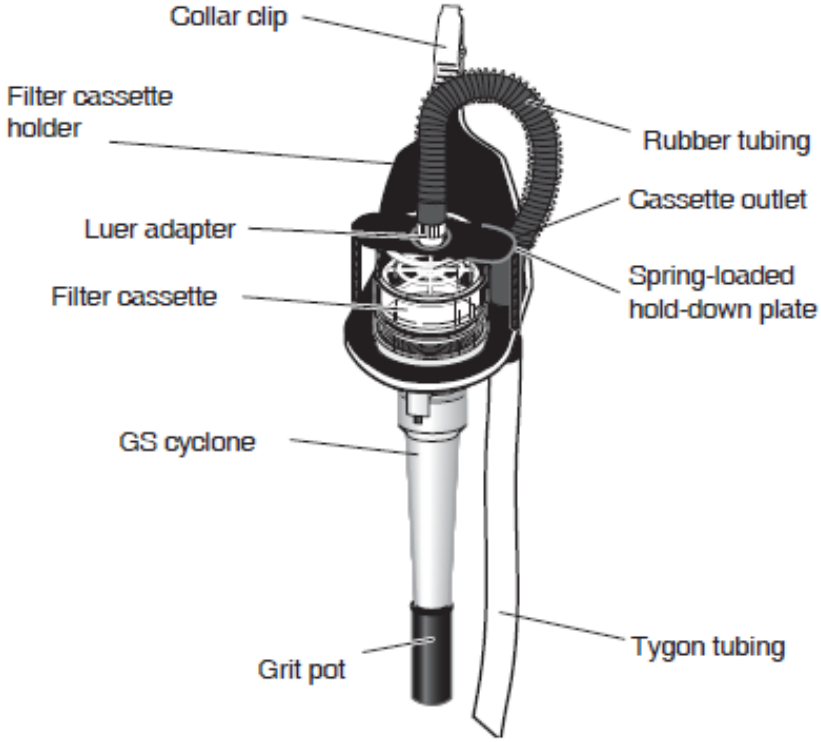


Figure 14. Typical Cyclone Assembly
(Pictures courtesy of SKC, Inc.)

Thoracic Particulates. Thoracic particulates are dust that can enter the tracheobronchial region and generally are smaller than 10 µm. Currently, there are no published standards that require thoracic aerosol sampling. However, with international agreement on what this fraction is with respect to the size distribution, such OEELs may soon follow. The only personal sampler for thoracic aerosols is the GK2.69, offered by BGI Incorporated. When such devices are used, the manufacturer should be consulted to determine the correct flow rate to collect a thoracic aerosol size distribution.

Inhalable Particulates. Inhalable particulates are the fraction of total workplace aerosol actually entering the respiratory tract. There are some TLVs® that are set for inhalable fractions. Three inhalable aerosol samplers are widely available including the Institute of Occupational Medicine (IOM) sampler, the button sampler (both distributed by SKC, Inc.), and the conical inhalable sampler distributed by BGI, Inc. The IOM sampler operates at 2 LPM, the button sampler at 4 LPM, and the conical inhalable sampler at 3.5 LPM. As more OEELs are set for inhalable aerosols, other samplers will likely be introduced. When such devices are used, the manufacturer should be consulted to determine the correct flow rate to collect an inhalable aerosol size distribution. Follow the manufacturer's recommendations for specific sampler assembly (typical IOM assembly is pictured in Figure 15), use, shipping, and handling. For the IOM, remove the cassette from the sampler and place the manufacturer's cover on the cassette. The loaded filter in the cassette without the IOM body can be protected properly in the transport clip and cover. Send

the cassette in the clip to the laboratory. The Chemistry Lab will clean and return all transport clips, covers, and inhalable particle samplers. For additional information on inhalable particles and beryllium, refer to the USAFSAM *Base Level Guide: Occupational Exposure to Beryllium* on the ESOH Service Center website.

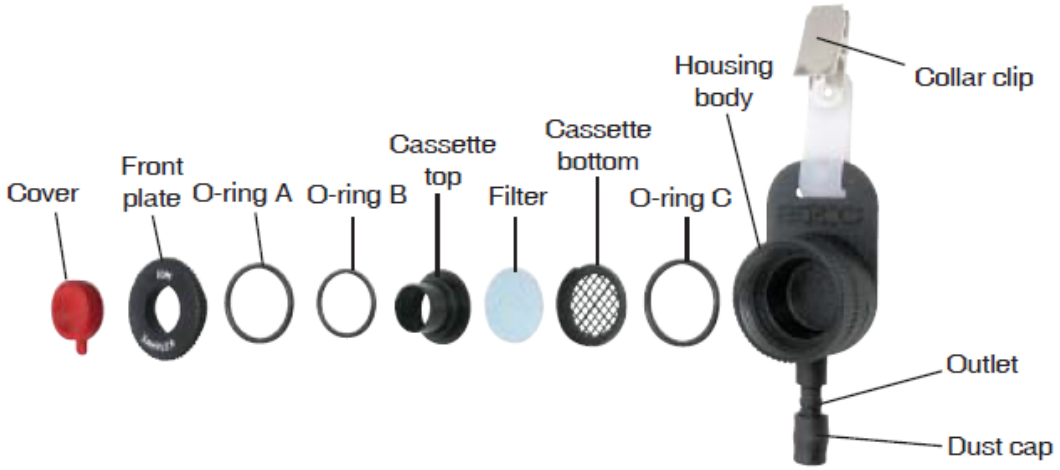


Figure 15. Typical IOM Sampler Assembly
(Pictures courtesy of SKC, Inc.)

When sampling with an IOM, remember the following tips:

- Follow the manufacturer's recommendations for shipping the sampler to the laboratory. After sampling, remove the cassette from the sampler and place the cover on the cassette (Figure 16). The loaded filter in the cassette without the IOM body can be protected in the transport clip and cover. Send the cassette in the clip to the laboratory.
- IOM field blanks should be treated in the same manner as the samples. Blanks should be placed in the cassette and transport cover.
- All media will be cleaned and returned by the laboratory. Allow 2 to 4 weeks for media to be shipped back to the customer.
- IOM calibration requires the use of the calibration adapter. Refer to the manufacturer's information for additional details.

Figure 16. IOM Transport Clip
(Pictures courtesy of SKC, Inc.)

"Total" Particulates. For total particulate sampling results, it is estimated that 60% of the particles available in the airstream are ultimately respirable. All OSHA PELs for "total" particulates are sampled with a closed-faced 37-mm filter cassette. Studies have shown that this sampling method collects fewer particulates than an inhalable sampler. Figure 17 depicts the inhalable, thoracic, and respirable aerosol penetration regions.

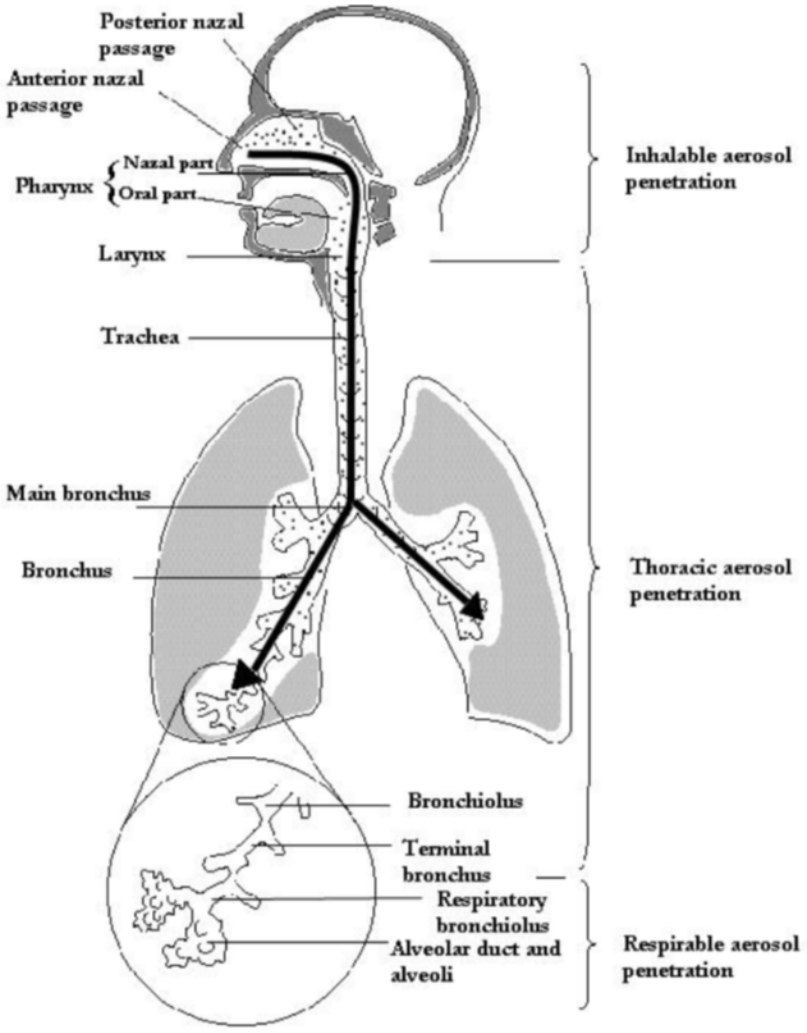


Figure 17. Respirable, Thoracic, and Inhalable Particulates
EPA Figure 4-1, APTI 435: Atmospheric Sampling Course

Gravimetric Analysis. NIOSH 0500 for total particulates and NIOSH 0600 for respirable particulates both use gravimetric analysis. Gravimetric analysis involves drawing a volume of air through a filter of known initial weight, then reweighing the filter after sampling to determine the mass captured. The average particulate concentration is the difference in beginning mass and ending mass divided by the volume of air sampled. Particulate samples collected for gravimetric analysis by NIOSH 0500 or 0600 MUST be collected on preweighed or matched-weight PVC or MCE filters. Care should be taken to not overload the filter.

- *Matched Weight.* Matched weight refers to two filters, either MCE or PVC, that are matched in weight and loaded into a cassette in a strictly controlled lab environment. The top filter collects contaminants and the bottom filter serves as a control. After sampling, both filters are removed and weighed individually; the difference between weights is the sample weight. The mass of particulates sampled is the difference between the collection filter and the control filter.

- *Preweighed PVC Filters.* Preweighed filters are weighed to within 5 decimals and are preloaded into cassettes in a strictly controlled lab environment. The cassettes are marked with weight and lot number. The mass of the particulates sampled is the ending mass minus the preweighed mass. ***Note:*** Preweighed media is the Chemistry Lab's preferred media for gravimetric analyses and is easily identified by a large label on the filter cassette listing the filter weight.

2.23 Metals in Air by Inductively Coupled Plasma

Analytical Services can perform metals analysis by NIOSH 7300 modified (Table 16) including the analytes listed below. Additional analytes may be available through a contract lab upon request (e.g., tin, uranium, etc.); contact Customer Service for additional information.

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Molybdenum
- Potassium
- Nickel
- Selenium
- Silver
- Strontium
- Thallium
- Titanium
- Vanadium
- Zinc

Table 16. Metals Air Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 7300 Modified	0.8-µm MCE *or* 5.0-µm PVC, 37-mm cassette	Indicate type of media used on sample submission paperwork. May use preweighed or matched-weight PVC media to obtain both particulate (NIOSH 0500 or 0600) and metal (NIOSH 7300) results from a single cassette.
Air	NIOSH 7300 Modified for Inhalable Beryllium	IOM sampler with 25-mm MCE filter, *or* button aerosol sampler, 25-mm MCE filter	When beryllium is indicated on sample submission paperwork, the lab will perform analysis by ICP-MS to obtain lower reporting limits unless instructed otherwise. Please indicate on the paperwork if the source of contamination is suspected to be high-fired beryllium. Allow 2 to 4 weeks for IOM and button samplers to be cleaned and returned. Provide return address on sample submission paperwork.

With the exception of beryllium, all analyses are conducted by ICP-OES unless otherwise specified by the customer. Sample submissions specifically requesting beryllium will be analyzed using ICP-MS to obtain the lowest available reporting limits.

Media. Metal air samples can be collected on either PVC or MCE media. It is important to indicate the type of media used on the paperwork sent to the lab. Laboratory control samples will be prepared on the same media used during sample collection.

Screens. The lab can analyze multiple metals on a single filter up to a full metals screen. The standard metals screen offered by the Chemistry Lab will include all metals listed above with the exception of magnesium and potassium. To correctly populate a DOEHRS Sample Submission Form for a metals screen, each metal must be individually identified as a process hazard. Alternatively, a single metal hazard may be selected for each sample and the comment "Please conduct a full metals screen" placed in the comment field. ***Note:*** For best results and to reduce the potential for interference, the list of requested metals should be limited based on knowledge of the industrial process.

Compounds. NIOSH 7300 modified can be used to determine concentrations of compounds in air using the equation in Section 2.17 (*e.g., $BaCl_2$, CuO, Fe_2O_3, MgO, MnO, $PbCrO_4$, and $SrCrO_4$).* ***Note:*** Some metal compounds and metal oxides are not completely digested using this method and may be underestimated (i.e., aluminum oxide, high-fired beryllium, etc.). Please contact the laboratory to discuss analysis options if you suspect these compounds are present in your sample.

Chromium. USAFSAM recommends measuring Cr(VI) exclusively with NIOSH 7605. NIOSH 7300 modified can only provide total chromium results. For details on Cr(VI) sampling, refer to the hexavalent chromium section in this guide.

Welding Fumes. When sampling for welding fumes, the filter cassette must be placed inside the welding helmet to obtain an accurate measurement of the employee's exposure. If, however, the welding helmet cannot be used as a sampling environment, the personal sampling pump cassette can be attached in the breathing zone at collar level. The resulting information can be used as a screening tool: "the air outside the helmet was (not) at a level of concern; therefore, the air inside the welding helmet was (not) at a level of concern." Welding fume samples are normally taken using 37-mm filters and cassettes; however, if these cassettes will not fit inside the helmet, 25-mm filters and cassettes can be used. Care must be taken not to overload the 25-mm cassette when sampling.

2.24 Hexavalent Chromium

NIOSH 7605 is exclusively recommended for Cr(VI) sampling (Table 17). Samples MUST be collected on PVC filters. Since high background concentrations on PVC filters are encountered routinely due to the manufacturing processes, media blanks should be submitted to the lab in addition to field blanks to determine the extent of preexisting contamination on the PVC filters in your particular lot. For best results, samples should be stored and shipped refrigerated. Samples are stable for 2 weeks at room temperature and 4 weeks if refrigerated. Cr(VI) hazards should be documented in DOEHRS by selecting "CHROMIUM HEXAVALENT ION." This is the analyte that should be listed under "Display Hazard Name" on the Discoverer Viewer sample submission form. Care should be taken to not overload the cassette during dusty operations (e.g., mechanical sanding of painted aircraft parts). For additional guidance on Cr(VI), refer to the latest *Hexavalent Chromium Technical Guide* on the ESOH Service Center website. ***Note:*** Wipe samples may be collected on either 5.0-µm PVC filters, Whatman 41, or Whatman 42 (55-mm or smaller) filter paper. Laboratory validation of Whatman filter papers indicated considerably less background of Cr(VI) versus PVC filters. The Chemistry Lab has not validated the use of SKC smear tabs or quartz fiber filters for Cr(VI) wipe sampling. This guidance supersedes the media recommended in the November 2011 *Hexavalent Chromium Technical Guide.*

Table 17. Hexavalent Chromium Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 7605	5.0-µm PVC, 37-mm cassette	Samples MUST be collected on PVC media. MCE filters physically dissolve in the laboratory desorption process. This creates a thick fluid that cannot be filtered or run through the chromatography column, which makes them impossible to analyze.
Bulk	Modified NIOSH 7605	Plastic or glass container	Should only be used in conjunction with a health risk assessment.
Settled Dust (Wipe)	Modified NIOSH 7605	Whatman 41/42 filters (<55 mm) or PVC filters	Samples MUST be collected on PVC media or Whatman 41/42 filter paper. Refer to the wipe procedures below and the *Occupational Hygiene: Contamination Control and Housekeeping Guide* for additional information.

2.25 Wipe Sampling

Guidance on the wipe sample collection varies based on the contaminant and analytical method. Below is the lab's recommended collection procedures based on popular analytes. For media other than those shown in Table 18, coordinate with Customer Service prior to sample collection to ensure the lab will be able to accommodate the request. The lab is not currently validated to conduct metals analysis on SKC smear tabs.

Compliance Wipes. Wipes used for the Environmental Lead Laboratory Accreditation Program must meet ASTM E1792 specifications. Ghost Wipes meeting these ASTM requirements are available through the Chemistry Lab by placing an order through Customer Service. Ghost Wipes should be used for sampling to meet ASTM specifications and all ELLAP requirements.

Metal Screens. The lab can analyze the metals listed in Table 18 on a single Whatman 41/42 (preferred) or MCE wipe sample. To correctly populate a DOEHRS Sample Submission Form with all metals, each metal must be individually identified as a process hazard. Alternatively, a single metal hazard may be selected for each sample and the comment "Please conduct a full metal screen" placed in the comment field. ***Note:*** For best results and to reduce the potential for interference, the list of requested metals should be limited based on knowledge of the industrial process.

Additional wipe sample guidance can be found in the *Occupational Hygiene: Contamination Control and Housekeeping Guide (Preliminary Guidance)* on the ESOH Service Center website.

Table 18. Wipe Sampling

Matrix	Method	Media	Analyte(s)
Settled Dust (Wipe)	EPA 6010C	Ghost Wipes	Lead *Note: Ghost Wipes shall be used when ELLAP and ASTM E1792 specifications must be met for compliance purposes.
Settled Dust (Wipe)	EPA 6010C	Whatman 41/42 filter paper or MCE filters	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium(Total), Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Titanium, Vanadium, Zinc
Settled Dust (Wipe)	Modified NIOSH 7605	Whatman 41/42 filter paper (<55 mm) or PVC filters	Hexavalent Chromium

Wipe Collection Procedures. The following basic procedures may be referenced when collecting wipe samples:

- ***Media***. Ghost Wipes may be ordered by contacting Customer Service; generally, the media will arrive the next business day. All other media should be ordered through local supply channels.
- ***Gloves***. Clean disposable gloves should be worn when handling the filters. The gloves should not be powdered. A new set of clean, impervious gloves should be used for each sample to avoid contamination of the filter by previous samples (and the possibility of false positives) and to prevent contact with the substance.
- ***Sketch***. If multiple samples are to be taken at the worksite, prepare a rough sketch of the area to be sampled. Usually use a 1-ft^2 or 100-cm^2 template.
- ***Vials***. Prepare a sufficient number of vials, each labeled with a unique number, for the projected sampling needs. If vials are not available, plastic bags may be used. Record the sample vial number and the location where the sample is taken.
- ***Sample Area***. Depending on the purpose of the sample, it may be useful to determine the surface loading of the contamination (i.e., in micrograms of analyte per area). For these samples, it is necessary to record the area of the surface wiped (e.g., 100 cm^2). This would not be necessary for samples taken to simply show the presence of the contaminant.
- ***Preparing the Media***. Remove the filter from the carrying container with clean PTFE-coated tweezers or plastic tweezers. Do not use metal tweezers to handle the filters, as they may deposit trace metals onto the filters. Samples should be taken wet for MCE and Whatman filters (dampen, do not saturate, with deionized water). If using premoistened wipes, there is no need to wet the media. For Cr(VI), wipes should be collected dry, as the water will allow any metal interferences to interact with the Cr(VI), thereby affecting the results. ***Do not*** sample using the blue separator sheets commonly found in commercially available MCE and PVC media.
- ***Swiping***. Firm pressure should be applied when wiping. Start at the outside edge and progress toward the center, making concentric squares of decreasing size. Fold the filter with the contaminant side inward and repeat. Without allowing the filter to come into contact with any other surface, fold the filter with the exposed side inward. Place the filter in a sample vial

or sealable plastic bag, cap or seal, and place a corresponding sample number and the location on the diagram. Include notes with the sketch, giving any further description that may prove useful when evaluating the sample results (e.g., a description of the surface sampled, such as pencil, doorknob, safety glasses, lunch table, inside respirator, employee names, etc.). ***Note:*** Do not write on the filters. All sample labeling should be done on the individual sample vials or sealable bags.

- ***Blanks***. At least one blank filter treated in the same fashion, but without wiping, should be submitted for each sampled area.

2.26 Jet Fuels and Other Naphthas

NIOSH 1550 is the preferred in-house method for the analysis of various types of hydrocarbon mixtures called naphthas including jet fuels (JP-8), petroleum ether, rubber solvent, petroleum naphtha, petroleum distillates mixtures, VM&P naphtha, mineral spirits, kerosene, coal tar naphtha, and stoddard solvents (Table 19). With the exception of JP-8, for best results submit a 5-mL bulk sample of the naptha. The analyst will use your bulk sample to prepare laboratory quality control samples. The lab will use an Air Force composite standard for all JP-8 quality control samples.

Be sure to ask specifically for what you are sampling (e.g., JP-8, mineral spirits, kerosene, etc.). If NIOSH 1550 is the only thing listed on the sample submission paperwork, your workorder will be delayed until Customer Service is able to obtain which specific naphtha you would like reported. Alternatively, a base may request "total hydrocarbons." For additional information specifically regarding jet fuels, refer to AFRL-SA-WP-SR-2012-0002, *Interim Base-Level Guide for Exposure to Jet Fuels and Additives,* available on the ESOH Service Center website. ***Note:*** Jet fuels may be present in *aerosol* form as well as vapor in colder climates. NIOSH 1550, which only collects fuel *vapors,* may significantly underestimate exposures in these climates.

Table 19. Jet Fuels and Other Naphtha Sampling

Matrix	Method	Collection Media	Comments
Air	NIOSH 1550	Anasorb CSC, Coconut Charcoal, 50/100 mg sorbent	Submit 5-mL bulk sample with air samples (except JP-8). Package bulk sample separately to prevent cross contamination. Identify specific naphtha to be analyzed on sample submission forms. Jet fuels (NIOSH 1550) and benzene (NIOSH 1501) may be sampled on a single tube.

Multiple contaminants can often be analyzed from a single sorbent tube if the analytical technique and desorption are the same. The lab routinely receives duplicate samples collected for benzene and JP-8 on separate sorbent tubes. Benzene by NIOSH 1501 and JP-8 by NIOSH 1550 can be collected on a single sorbent tube since they are both analyzed by GC/FID with carbon disulfide desorption. The only available analytical method in DOEHRS for both JP-8 and benzene is listed as NIOSH 1501. However, if NIOSH 1501 is selected in DOEHRS, then bases should list NIOSH 1550 for benzene in the comments section of the sample submission form as well since this is the analytical laboratory's reference method.

2.27 Isocyanates

The Iso-Chek® sampling protocol is the recommended sampling method for isocyanates including both the monomer and oligomer forms listed in Table 20 below. Iso-Chek® (SKC Inc., Eighty Four, PA) uses a two-stage filter arrangement that results in the separation of vapor from aerosol

(Figure 18). Stage one contains an untreated PTFE filter to collect the aerosol phase, and stage two holds a glass fiber filter impregnated with 9-(N-methylaminomethyl) anthracene for the vapor phase of isocyanates. The required flow rate is 1 LPM, with a maximum volume of 15 liters. This is important to note since it will drive a high filter change-out frequency, i.e., every 15 minutes. Very low concentrations (less than 1 ppb) may be sampled at 2 LPM for 30 minutes. For additional details on isocyanates, refer to AFRL-SA-WP-SR-2012-003, *Base Level Guide for the Occupational Exposure to Isocyanates* on the ESOH Service Center website.

Table 20. Isocyanates Available Using the Iso-Chek® Protocol

Isocyanate	
1,6-HDI	1,6 Hexamethylene Diisocyanate
MDI	Methylene Diphenyl Diisocyanate
IPDI	Isophorome Diisocyanate
2,4-TDI	2,4 Toluene Diisocyanate
2,6-TDI	2,6 Toluene Diisocyanate

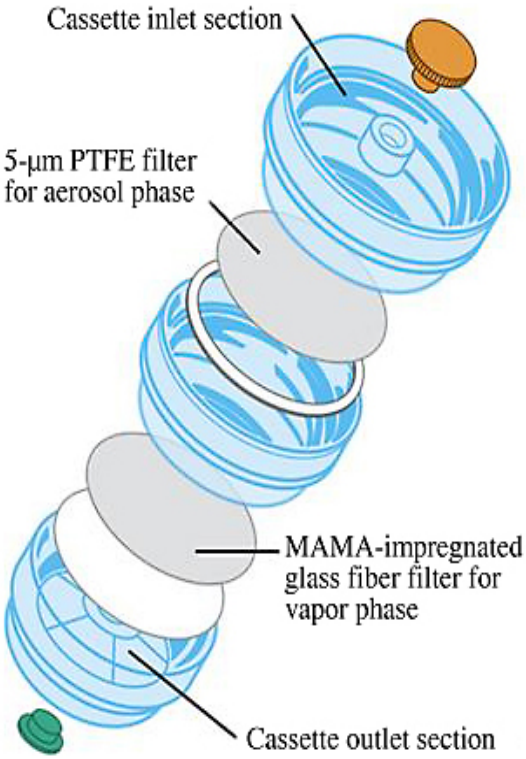


Figure 18. Iso-Chek® Cassettes
Image courtesy of SKC, Inc.

When collecting isocyanate samples using the Iso-Chek® protocol, follow the step-by-step procedures prepared by the SKC Omega Specialty Division that are included in the original sampling supply kit from the manufacturer. The sampling procedures may also be accessed online through the Omega Specialty Instrument Co.

Note: Isocyanate sampling (Table 21) has a very high sample collection and submission error rate. Attention to detail and strict adherence to the protocol are required to ensure the validity of sample results. Below are key points to remember when sampling using the Iso-Chek® protocol:

Table 21. Isocyanate Sampling

Matrix	Method	Collection Media	Comments
Air	**ISO-CHEK®,** *1,6-HDI, MDI, IPDI, 2,4-TDI, 2,6-TDI*	Dual filter cassette, 5.0-µm PTFE filter, 9-(N-methylaminomethyl) anthracene impregnated glass fiber filter Sample kits can be ordered from SKC (225-9023 or 225-9023A)	Transfer PTFE filter to the reagent jar immediately after sampling and protect sample from light (wrap in aluminum). Be sure to order the Iso-Chek® kit that includes derivatizing solution. Store cold and ship with gel packs to the lab as soon as possible. Unrefrigerated samples are stable for 7 days; refrigerated samples are stable for 7 to 10 days.

- Bases should request the Iso-Chek® protocol and list the specific isocyanate desired (e.g., 1,6-HDI, MDI, etc.) on sample submission paperwork. The default analytical report will include both monomer and oligomer fractions of the selected analyte.
- Be sure to order Iso-Chek® kits that include the derivatizing solution (SKC 225-9023 or 225-9023A).
- Unplug and connect the cassette to a sample pump calibrated to 1 LPM.
- Take a 15-minute sample.
- Immediately after sampling, open the cassette and remove the PTFE filter with forceps (filter closest to air inlet). Do not remove the washer-style support pad from the cassette.
- Match the cassette ID number with the reagent jar number; place the filter in the prepared jar containing the methoxy-2-phenyl-1 piperazine reagent in toluene.
- Keep the fiberglass filter in the cassette.
- Replug the cassette; wrap it in foil to protect the sample from light.
- Label both the cassette and corresponding reagent jar with the same DOEHRS sample ID.
- Prepare a field blank in the same manner, with the PTFE filter removed and placed in the reagent jar.
- Store collected samples in the refrigerator until ready for shipping.
- Ship all jars *and* cassettes to the laboratory as soon as possible (same business day). The manufacturer's original shipping container works well for sending field samples to the laboratory.
- DOT regulations require that material able to absorb the solvent be packed with the jars in case of a leak. The blue foam in the original shipping packaging meets this requirement. DOT regulations also require that the package be placed in another cardboard box prior to shipment. Use the 40 CFR 173.4 labels provided by the manufacturer to ship the package.

- To extend sample stability, ship samples with gel packs. Refrigerated samples are stable for 7 to 10 days. Contact Customer Service *prior* to shipping samples if they will arrive at the lab within 48 hours of the hold time expiring.
- Do not ship samples on Fridays. USAFSAM/OEA is not able to accept routine Saturday deliveries. Refrigerated samples shipped overnight on Friday will not be received by the lab until Monday morning.

2.28 Mold Sampling

Periodically, Analytical Services receives a request to conduct mold sampling in conjunction with an occupational illness investigation. Mold sampling is generally not recommended, and in accordance with the 10 May 2005 Surgeon General *Interim Policy and Guidance for the Prevention, Surveillance, and Remediation of Water Damage and Associated Mold Contamination in Air Force (AF) Facilities*, sampling "should only be accomplished as the result of consultation with the physician/health care provider and an occupational medicine physician or allergist in order to provide information that supports a specific clinical diagnosis or aids in medical treatment." Additionally, the Surgeon General policy continues to state, "Microbial sampling and analysis has significant limitations and may not be a predicator of indoor air related health problems. There are currently no industry or legal standards for acceptable microbial concentrations in buildings." In the rare event sampling is required, contact Customer Service to discuss sampling options.

SECTION 3: ENVIRONMENTAL HEALTH

3.0 Environmental Health Sampling

Environmental health samples are collected to assess either ambient environmental conditions (e.g., sand in New Mexico, smog in Los Angeles, radon in Colorado), industrial operations located either inside or outside the area of concern (AOC), or conditions that affect large portions of the AOC. A variety of sampling techniques could be used to sample environmental concerns (24+ hour air samples, soil, surface, and drinking water). The techniques will be based on the contaminants and are up to the discretion of the risk assessor. Environmental health (EH) samples are assigned to a location; personnel are linked to the possible exposure through the location.

3.1 Environmental Health Analytical Services

Analytical Services meets the demand for EH analytical services both through in-house Chemistry Lab capabilities and through a network of contracted commercial labs. These capabilities span the full spectrum of commercially available analytical techniques. The contract can often be modified to meet the emerging and new technology demands of the field. For a general idea of the commercial services available, you may reference the sampling guides for the three major contract labs used by USAFSAM, including Test America, Bureau Veritas North America, and UL. These links are provided as a general reference; Customer Service ***must*** be contacted to address any questions and will make the final determination regarding the use of a commercial lab. Some of the more common analytical methods are referenced in each of the applicable sections below, including drinking water, surface and ground water, air, and soil sampling.

3.2 Use of Commercial Labs

USAFSAM/OEA is DHP funded to cover EH sampling on a limited basis. As mentioned in Section 1 of this guide, the use of a commercial lab ***must*** be coordinated with Customer Service ***prior*** to sample collection during the sample strategy planning phase. Unlike AIHA industrial hygiene nationally accredited labs, environmental laboratories are certified on a state-by-state basis. Contact Customer Service for assistance in locating a commercial lab to meet all your local requirements.

Commercial labs often require the customer to use a lab-supplied sampling kit and chain of custody (COC). Customer Service will walk the customer through the sampling process from sample kit/supply delivery, collection, shipping, and receipt of final results. While the *DOEHRS Discoverer Viewer Sample Submission Workbook* is the preferred COC for in-house occupational health analyses, a COC provided by the commercial lab may be required for EH sample submissions. Customer Service will coordinate COC requirements with the base.

3.3 Federal Regulations

While BEs no longer collect environmental compliance samples, it is beneficial to understand the basic Federal regulations governing environmental compliance and associated sampling and analysis. Having an understanding of the governing standards will aid in the development of an appropriate environmental health risk assessment sampling strategy. Federal environmental legislation (Table 22) that includes sampling and analysis is largely covered under five main acts:

Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Resource Conservation and Recovery Act (RCRA), Clean Air Act (CAA), and the Toxic Substances Control Act (TSCA). References to the EPA analytical methods are found in each applicable section below. For a compiled index of national environmental methods, refer to ASAGE or the collaborative National Environmental Methods Index hosted by the U.S. Geological Survey Water Resources Discipline, the EPA Office of Water, and the Center for Integrated Data Analytics. Each piece of legislation is discussed in detail in the following sections.

Table 22. Federal Environmental Legislation

Environmental Media	CWA	SDWA	RCRA	CAA	TSCA
Wastewater, Sewage Sludge	X		X		
Ground Water		X	X		
Drinking Water		X			
Storm Water	X				
Soil, Sludge			X		X
Solid Waste			X		X
Waste Oil			X		
Air				X	

3.3.1 Clean Water Act. The CWA establishes the basic structure for regulating discharges of pollutants into waters of the United States and regulating quality standards for surface waters. Under the CWA, the EPA has implemented pollution control programs such as setting wastewater standards for industry. They have also set water quality standards for all contaminants in surface waters. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges. The analytical methods promulgated under the authority of Section 304(h) of the CWA are sometimes referred to as the "304(h)" or "Part 136" methods. The methods measure chemical and biological pollutants in media such as wastewater, ambient water, sediment, and biosolids. A complete listing of CWA methods can be found on the EPA Clean Water Act Analytical Methods website.

3.3.2 Safe Drinking Water Act. The SDWA was established to protect the quality of drinking water in the United States. The law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The act authorizes the EPA to establish minimum standards to protect tap water and requires all owners or operators of public water systems to comply with these primary (health-related) standards. Water systems must use EPA-approved analytical methods when analyzing samples to meet Federal monitoring requirements or to demonstrate compliance with drinking water regulations. A list of approved methods for the analysis of drinking water samples can be obtained on the EPA Drinking Water Analytical Methods website.

3.3.3 Resource Conservation and Recovery Act. The RCRA, which amended the Solid Waste Disposal Act, regulates the management of solid and hazardous waste to protect public health and the environment. This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also requires substances identified as hazardous wastes be tracked with a "cradle-to-grave" manifest system. EPA Publication SW-846 is the official compendium of analytical and sampling methods for hazardous waste characterization that have been evaluated and approved for use in complying with the RCRA regulations. For BE operations, SW-846 methods can be used not for compliance but rather to characterize solid and potentially hazardous waste in association with an environmental HRA.

3.3.4 Clean Air Act. The CAA is the comprehensive Federal law that regulates air emissions from stationary and mobile sources. Among other things, this law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants. The 1990 amendments to the CAA list 187 toxic air pollutants, not previously regulated under the NAAQS. Asbestos demolition and renovation also fall under the CAA umbrella. A list of approved air toxic analytical methods can be found on the EPA Ambient Monitoring Technology Center and the Inorganic (IO) Compendium Methods page.

3.3.5 Toxic Substances Control Act. The TSCA gives the EPA the broad authority to regulate the manufacture, use, distribution, and disposal of chemical substances and is intended to protect the public from unknown development of dangerous new chemicals. The TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), chlorofluorocarbons, asbestos, radon, and lead-based paint. Test methods for PCBs can be found in the TSCA.

3.4 Sample Plan Development and the Data Quality Objectives (DQO) Process

The EPA DQO process can be a useful tool to develop an environmental sampling plan. This process establishes specific objectives for an environmental study and focuses data collection and analysis to meet those objectives. The DQO process achieves two major objectives: it ensures that the type, quantity, and quality of data collected are appropriate for the decision at hand; and it eliminates the collection of unnecessary, redundant, and overly precise data. The DQO process is defined in the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, and summarized in Figure 19.

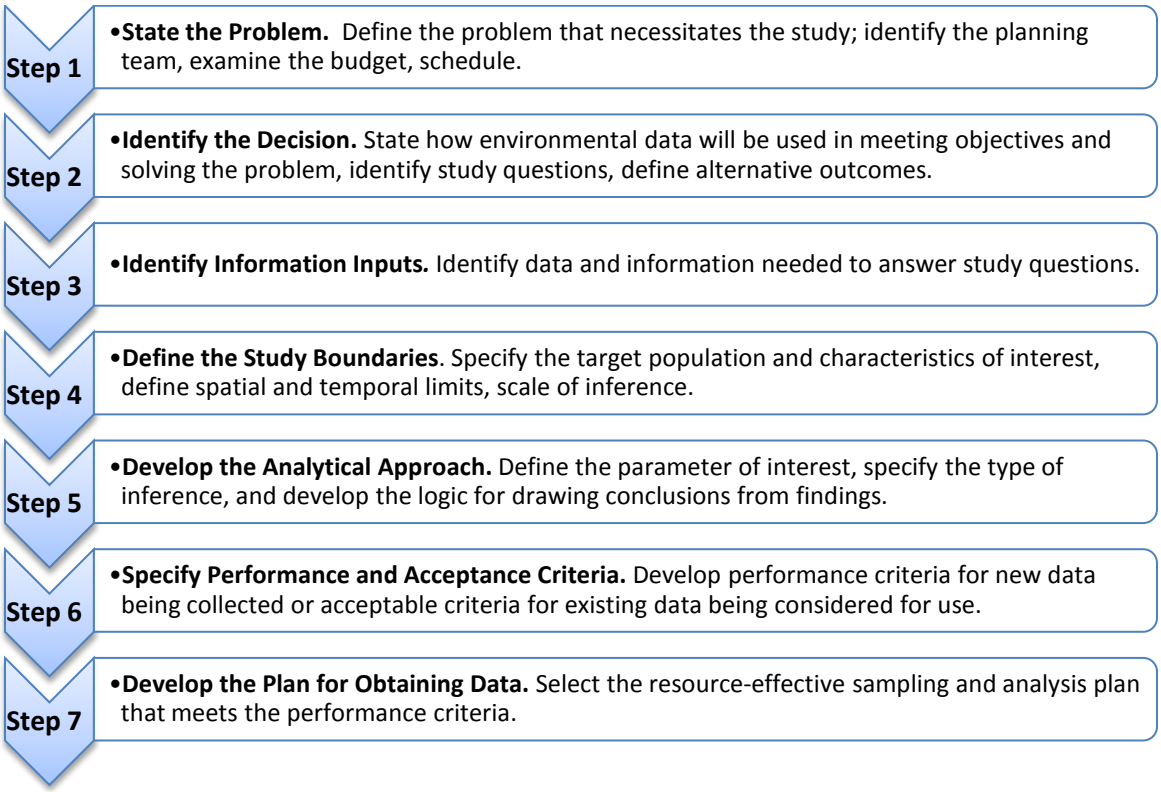


Figure 19. Sample Planning and the DQO Process

3.4.1 DQO Step 1: State the Problem. Before developing a detailed sampling plan, the first step is to state the problem or determine what question or questions are to be answered by the environmental risk assessment. During this step, also identify available BE resources for sampling and the primary decision makers (e.g., commanders, public health, flight medicine, etc.). Give a concise description of the environmental health threat and exposure pathway. Summarize existing information into a conceptual site model including previous sampling information, preliminary estimates, and process descriptions. A conceptual site model should be a three-dimensional "picture" of site conditions at a discrete point in time (snapshot) that conveys what is known or suspected about the facility, releases, release mechanisms, contaminant fate and transport, exposure pathways, potential receptors, and risks. Refer to the Occupational and Environmental Health Site Assessment (OEHSA) *Documentation and Data Management Technical Guide* on the Knowledge Exchange for additional details.

3.4.2 DQO Step 2: Identify the Decision. In step 2 of the DQO process, the goal of the study is identified. Specifically for sampling and analysis, what do you intend to do with the analytical results? State the questions you intend to answer with qualitative and/or quantitative results. Consider alternative outcomes and courses of action based on varying sampling results.

3.4.3 DQO Step 3: Identify Inputs to the Decision. In most cases, it will be necessary to collect data or new information to achieve the risk assessment goal. Examples of information gathering include available sampling/analysis methods, candidate sampling devices, risk assessment standards/OEELs, and required detection limits. Possible OEELs are discussed below. Additional information regarding matrix specific analytical methods and sample collection equipment is discussed later in this document.

Researching applicable OEELs is typically a critical part of DQO step 3. Below is a list of possible environmental risk assessment standards and toxicological information to aid selecting an appropriate OEEL for environmental hazards. This information is also summarized in Table 23.

- *Agency for Toxic Substance and Disease Registry (ASTDR) Minimal Risk Levels* are probably the best guide for community exposure. ASTDR derives minimal risk levels (MRLs) for noncancer toxic effects. MRLs are estimates of daily human exposures that are considered to be without an appreciable risk of adverse effects over a specified duration of exposure. MRLs are derived for acute (14 days or less), intermediate (15-364 days), and chronic (365 days or more) exposures for inhalation and oral routes. MRLs are set below levels that, based on current information, might cause adverse health effects in the people most sensitive to such substance-induced effects.

- *U.S. Army TG 230, Air, Water, and Soil Military Exposure Guidelines (MEG)*. These standards are based on toxicological studies and can assist in making a risk-based decision during deployments and while in-garrison. Values in these tables are associated with threshold effects relative to the health effects of the given chemical. TG 230 addresses chemical hazards to include chemical warfare agents, acutely toxic industrial chemicals, and a wide array of general environmental pollutants. The guide does not address biological or nuclear/radiation hazards. There is a Reference Document 230 that provides details associated with the methods, scientific rationale, and assumptions behind the established MEGs.

Table 23. Possible Sources for Establishing OEELs for Environmental HRAs[a]

Guideline	Target	Author	Summary	Duration
MEG	Military	USAPHC	Deployed exposure guidelines, TG-230	From 10 min to 1 yr
AEGL	Public	COT National Research Council	Three-tier guideline for emergency response	10 min, 30 min, 1 h, 4 h, and 8 h
ERPG	Public	AIHA	Three-tier planning guideline for emergency response	1 h
1/10 IDLH	Public	EPA/FEMA/DOT	LOC estimation based on IDLH	30 min
NAAQ	Public	EPA	U.S. primary air quality standards	Lifetime
CAA-HAP	Public	EPA	U.S. primary hazardous air pollutant standards	Lifetime
AFI 48-138	Military	Tri-Service	Field water guidelines	7 and 14 days
IRIS	Public	EPA	References does for noncarcinogenic toxicity and carcinogenic potency factors	Lifetime
MCL	Public	EPA	U.S. primary safe drinking water standards	Lifetime
MRL	Public	ASTDR	Noncancer toxic effects for community exposures	<14 days; 15-364 days; >365 days
TLV **PEL** **REL**	Worker	ACGIH, OSHA, NIOSH	Occupational exposure for 8-h workday	8 h/day, 20 to 30 yr

MEG- Military Exposure Guideline, Technical Guide 230, U.S. Army Public Health Command
AEGL- Acute Exposure Guidelines, National Research Council's Committee on Toxicology
ERPG- Emergency Response Planning Guideline, American Industrial Hygiene Association
IDLH- Immediately Dangerous to Life or Health, National Institute for Occupational Safety and Health
NAAQ- National Ambient Air Quality Standards
CAA-HAP- Clean Air Act Hazardous Air Pollutants
AFI- Air Force Instruction
IRIS- Integrated Risk Information System, Environmental Protection Agency
MCL- Maximum Contaminant Level, Environmental Protection Agency
MRL- Minimal Risk Levels, Agency for Toxic Substance and Disease Registry
TLV- Threshold Limit Value, American Conference of Governmental Industrial Hygienists
PEL- Permissible Exposure Limit, Occupational Safety and Health Administration
REL- Recommended Exposure Limit, Occupational Safety and Health Administration

[a]Table adapted from Eninger & Ott, *Operational Risk Assessment (2011).*

- *U.S. EPA National Ambient Air Quality Standards*. NAAQS regulate air quality while in-garrison, and exposures should be documented. These regulations may not apply while deployed; however, the information can be used to guide the health risk assessment. NAAQS are divided into clean air primary standards and secondary standards. Primary standards are designed to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards are established to protect public welfare, including protection against decreased visibility and damage to animals, crops,

vegetation, and buildings. NAAQS have been established for six principal criteria pollutants including nitrogen dioxide, ozone, sulfur dioxide, particulate matter (PM), carbon monoxide (CO), and Pb.

- *EPA Maximum Contaminant Levels (MCLs).* MCLs are standards that are set by the EPA for drinking water quality. An MCL is the legal threshold limit on the amount of a substance that is allowed in public water systems under the SDWA. MCLs ensure that drinking water does not pose a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible.

- *ACGIH® TLVs® and OSHA PELs*. These regulations are enforceable in-garrison, and compliance is mandatory. While OSHA regulations are not enforceable in some deployed locations, it is important to consider OSHA PELs and ACGIH® TLVs® when assessing the exposures from local environmental and industrial activities. It is important to remember these standards were promulgated on the basis of an 8-hour/day, 5-day/week work week for employees conducting the task generating the hazard. These values may not be appropriate for general populations but may provide valuable information during the environmental health risk assessment.

- *EPA Integrated Risk Information System*. IRIS is a human health assessment program that evaluates risk information on effects that may result from exposure to environmental contaminants. The IRIS database contains information for more than 550 chemical substances and the associated human health effects resulting from environmental exposures. IRIS provides reference doses for noncarcinogenic toxicity and slope factors (carcinogenic potency factors) for carcinogens.

3.4.4 DQO Step 4: Define the Study Boundaries. It is important to clearly define the AOC to be sampled including spatial boundaries (number of acres, miles of shore line, gallons of pond water, etc.) and temporal boundaries (seasonal variances, volatilization rate, etc.). Define the media to be sampled, such as air, water, or soil, and the sampling unit as some area, volume, or mass that must be collected. Define the physical area to be studied and generally where samples will be collected and the time frame when the samples should be taken. Select a sampling device based on its ability to (1) obtain the correct size, shape, and orientation of the sample and (2) meet other performance goals specified by the planning team.

3.4.5 DQO Step 5: Develop a Decision Rule. The main objective of step 5 of the DQO process is to select a result parameter and action level. These two should then be combined to develop the decision rule (see Table 24).

Result Parameter. The sample results parameter is the parameter (mean, median, or upper confidence limit) that will be used with the HRA: Are you interested in "average" conditions or "extreme, worst-case" conditions? The statistical parameter (mean, median, percentile) selected in step 5 can be based on what the AL is intended to represent. In general, if an AL is based on long-term average health effects, the parameter of interest could be the mean sample value. If the AL represents a value that should never (or rarely) be exceeded, then the parameter of interest could be an upper percentile, which can serve as a reasonable approximation of the *maximum* value.

Table 24. Result Parameters and Their Applicability to a Decision Rule[a]

Parameter	Definition	Appropriate Conditions of Use
Mean	Average	Estimate central tendency, compare middle part of population to an AL. Appropriate for a chemical that could cause cancer after a long-term chronic exposure. Use of the mean and the total amount of media (i.e., mass of soil or water) allows you to estimate the total amount of contaminant contained in the soil or water body. The mean is greatly influenced by extremes in the contaminant distribution and not very useful if a large portion of values are below the detection limit.
Median	Middle observation of the distribution; 50^{th} percentile; half of sample results are above and below	Better estimate of central tendency for a population that is highly skewed (nonsymmetrical). Also may be preferred if the population contains many values that are less than the measurement detection limit. However, the median is not a good choice if more than 50% of the population is less than the limit of quantitation because a true median does not exist in this case. The median is not influenced by the extremes of the contaminant distribution.
Percentile	Specific percent of sample that is equal to or below the given value	For cases where it is necessary to demonstrate that, at most, only a small portion of a population could exceed the AL. Sometimes selected if the decision rule is being developed for a chemical that can cause acute health effects. Also useful when a large part of the population contains values less than the detection limit. Often requires larger sample sizes than mean or median.

[a]Adapted from Table 5-1 from EPA QA/G-4, Guidance for the Data Quality Objectives Process (Aug 2000)

Action Level. Define the AL, either using a predetermined AL from fixed standards such as a published drinking water MCL or using a more conservative investigation-based AL, e.g., $1/10^{th}$ of the OEEL. Document the detection limits for the analytical methods identified in step 3. If the detection limit for the method exceeds or is very close to the AL, then a more sensitive method should be used.

Decision Rule. The AL and the result parameter should be combined to construct the *"If…then…else…"* decision rule. An example of a decision rule is as follows:

If the mean concentration in the surface 2 inches of soil area defined as 20 feet by 100 feet exceeds 1 ppb, ***then*** remove a 6-inch layer of soil, ***else*** leave the soil intact.

3.4.6 DQO Step 6: Specify Performance or Acceptance Criteria. Identify sources of error (e.g., sampling error, analytical error, etc.). Determine the desired confidence level in your results before collecting samples (e.g., 99%, 95%, 90%, 80%, or 70% confident that a correct decision is being made). Identify the gray area (typically in AF operations this is the range between the AL and the OEEL).

3.4.7 DQO Step 7: Develop the Plan for Obtaining Data. Step 7 incorporates the outputs from steps 1-6 into a resource-effective sampling plan that will meet or exceed the objectives. This step summarizes previous steps and outlines the field sampling plan including:

- Number of samples
- Sample design
- General collection techniques
- Sample matrix and quantity
- Sample locations
- Timing issues for sample collection, handling, and analysis
- Analytical methods
- Statistical sampling scheme

Common pitfalls to avoid during sample plan development include (1) nonrepresentative sampling, (2) instability or contamination of samples between sampling and analysis, (3) interferences and matrix effects in analysis, (4) inability to determine the relevant forms of the parameter being measured, (5) improper calibration, and (6) failure to blank-correct.

3.5 Probability-Based vs. Judgmental Sampling Designs

There are two classes of sampling designs to consider: probability based and judgmental. The former are sometimes called statistical designs, while the latter is directed sampling information. The two classes have very different properties. Strong statistical conclusions are available with probability-based designs but not with judgmental designs. Use of professional expertise and/or historical knowledge about the site can improve development of statistical and judgmental sampling designs. Key questions to be considered are:

- Is the objective of the sample to estimate an average or to find a hot spot?
- Is there a reference or background population that can be used as a comparison to the target population?
- Will sampling sites be chosen ahead of time or in the field based on visual or other evidence; if the latter, what are your criteria for selection?
- Is the AOC homogeneous or is it heterogeneous in nature needing stratification or division into approximately homogeneous areas?
- Can samples be composited?

Table 25 summarizes the advantages and disadvantages of using probability-based and judgmental sampling designs.

Table 25. Probability-Based vs. Judgmental Sample Designs[a]

	Probability-based	Judgmental
Advantage	• Provides ability to calculate uncertainty associated with estimates • Provides reproducible results within uncertainty limits • Provides ability to make statistical inferences • Can handle decision error criteria	• Can be less expensive than probabilistic designs • Can be very efficient with knowledge of the site • Easy to implement
Disadvantage	• Random locations may be difficult to locate • An optimal design depends on an accurate conceptual site model	• Depends upon expert knowledge • Cannot reliably evaluate precision of estimates • Depends on personal judgment to interpret data relative to study objectives

[a]Adapted from Table 2-1 from EPA QA/G-5S, Guidance on Choosing a Sampling Design for Environmental Data Collection (Dec 2002)

3.5.1 Judgmental Sampling. In judgmental sampling, the selection of the number, location, and timing of sampling collection is based on knowledge of the feature or condition under investigation and on professional judgment (Figure 20). Conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment; probabilistic statements about parameters are not possible. Expert judgment may also be used in conjunction with other sampling designs to produce effective sampling for defensible decisions.

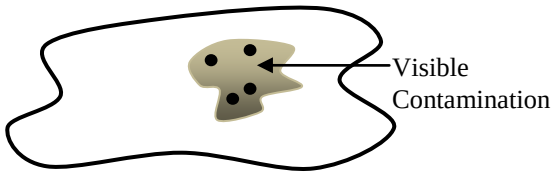


Figure 20. Judgmental Sampling

3.5.2 Simple Random Sampling. In simple random sampling, particular sampling units (e.g., locations, time, etc.) are selected using random numbers, and all possible selections of a given number of units are equally likely (Figure 21). For example, a simple random sample of a set of drums can be taken by numbering all the drums and then, using a random number generator, selecting the drums to be sampled. This method is easy to understand, and the equations for determining sample size are relatively straightforward. An example is shown in Figure 21. This figure illustrates a possible simple random sample for an area of soil. Simple random sampling is most useful when the population of interest is relatively homogeneous, e.g., no major patterns of contamination or "hot spots" are expected.

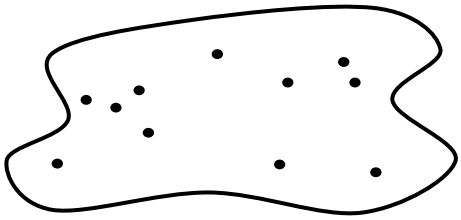


Figure 21. Simple Random Sampling

3.5.3 Stratified Sampling. In stratified sampling, the target population is separated into nonoverlapping strata, or subpopulations, that are known or thought to be more homogeneous (relative to the environmental medium or the contaminant), so there tends to be less variation among sampling units in the same stratum than among sampling units in different strata (Figure 22). Strata may be chosen on the basis of spatial or temporal proximity of the units or on the basis of preexisting information or professional judgment about the site or process. Advantages of this sampling design are that it has potential for achieving greater precision in estimates of the mean and variance and that it allows computation of reliable estimates for population subgroups of special interest.

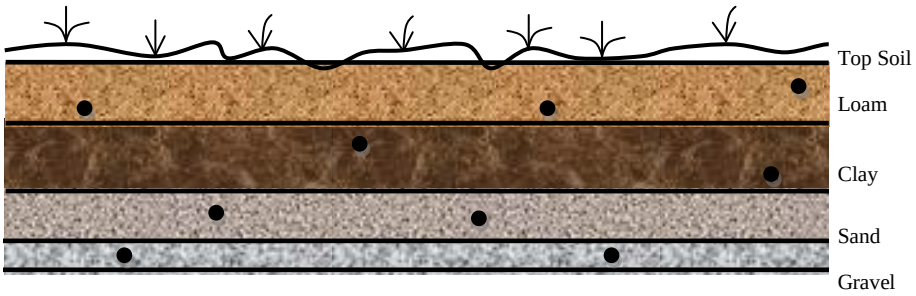


Figure 22. Stratified Random Sampling

3.5.4 Systematic and Grid Sampling. In systematic and grid sampling, samples are taken at regularly spaced intervals over space or time (Figure 23). An initial location or time is chosen at random, and then the remaining sampling locations are defined so that all locations are at regular intervals over an area (grid) or time (systematic). Systematic and grid sampling is used to search for hot spots and to infer means, percentiles, or other parameters and is also useful for estimating spatial patterns or trends over time. This design provides a practical and easy method for designating sample locations and ensures uniform coverage of a site, unit, or process.

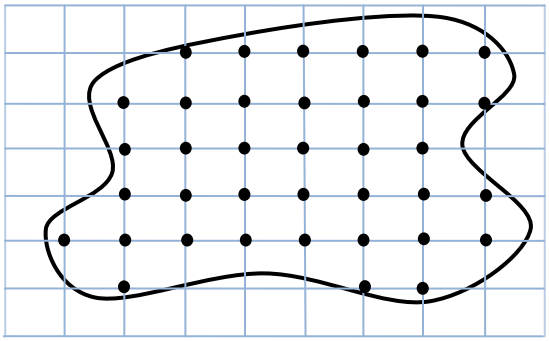


Figure 23. Systematic and Grid Sampling

3.5.5 Advanced Probabilistic-Based Sampling Designs. Two advanced probabilistic-based sampling designs include ranked set sampling and adaptive cluster sampling. Ranked set sampling uses a two-phase sampling design that identifies sets of field locations, utilizes inexpensive measurements to rank locations within each set, and then selects one location from each set for sampling. In adaptive cluster sampling, *n* samples are taken using simple random sampling, and additional samples are taken at locations where measurements exceed some threshold value. For additional information on these two advanced sampling designs, refer to EPA QA/G-5S.

3.5.6 Composite Sampling. In composite sampling, volumes of material from several of the selected sampling units are physically combined and mixed in an effort to form a single homogeneous sample, which is then analyzed (Figure 24). Compositing can be very cost effective because it reduces the number of chemical analyses needed. Compositing is often used in conjunction with other sampling designs when the goal is to estimate the population mean and when information on spatial or temporal variability is not needed.

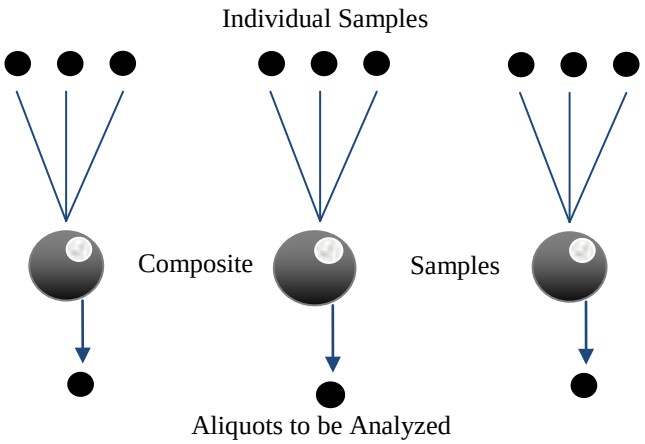


Figure 24. Composite Sampling

3.5.7 Choosing a Sampling Design. Table 26 summarizes the various sampling designs and can be used to aid in selecting a design based on site specific requirements.

3.6 Visual Sample Plan Software

When probability-based sampling designs are desired, one resource available to assist BEs is the Visual Sample Plan (VSP®) software program developed cooperatively between the Department of Energy, EPA, Department of Homeland Security, the Centers for Disease Control and Prevention, and the United Kingdom. VSP® is available for free download at http://vsp.pnnl.gov/. VSP® is a software tool that supports the development of a defensible sampling plan based on statistical sampling theory and statistical analysis of sample results to aid in decision making. VSP® is suited for larger scale sampling events and has many sampling design and statistical analysis modules focused on soils, sediments, surface waters, streams, ground water, and buildings. The underlying software methodology employs the Data Quality Objectives discussed in this guide.

3.7 Quality Control Samples

3.7.1 ***Background Samples.*** Background samples are collected at or near the AOC in areas not influenced by site contamination. They demonstrate the ambient concentrations of a substance from both naturally occurring and anthropogenic nonsite sources. Background samples are collected from each media of concern: soil, sediment, surface water, ground water, and air. The sample locations should have the same basic characteristics as the medium at the site. The number of background samples is site specific and dependent on the media samples, the type of contaminant, and the availability of background sample locations.

3.7.2 ***Field Quality Control Samples.*** A number of field quality control samples should be taken during environmental health sampling. The specific quantity of quality control samples should be determined as part of the sample plan prior to the start of field activities. For additional details on when to send blank samples, contact Customer Service. A general discussion on the type of QC samples is included in Table 27 and below:

Table 26. Choosing a Sampling Design[a]

If you are…	And you have…	Consider using…	To…
Performing a screening phase of an investigation of a relatively small-scale problem	A limited budget and/or a limited schedule	Judgmental sampling	Assess whether further investigation is warranted that should include a statistical probabilistic sampling design
Developing an understanding of *when* contamination is present	An adequate budget for the number of samples needed	Grid sampling	Acquire coverage of the *time* period of interest
Developing an understanding of *where* contamination is present	An adequate budget for the number of samples needed	Grid sampling	Acquire coverage of the area of concern with a given level of confidence that you would have detected a hot spot of a given size
Estimating a population mean	An adequate budget	Systematic or grid sampling	Also produce information on spatial or temporal patterns
	Budget constraints and analytical costs that are high compared to sampling costs	Composite sampling	Produce an equally precise or a more precise estimate of the mean with fewer analyses and lower cost
	Budget constraints and professional knowledge or inexpensive screening measurements to assess the relative amounts of the contaminant at specific field sample locations	Ranked set sampling	Reduce the number of analyses needed for a given level of precision
Estimating a population mean or proportion	Spatial or temporal information on contaminant patterns	Stratified sampling	Increase the precision of the estimate with the same number of samples, or achieve the same precision with fewer samples and lower cost
Delineating the boundaries of an area of contamination	A field screening method	Adaptive cluster sampling	Simultaneously use all observations in estimating the mean
Estimating the prevalence of a rare trait	Analytical costs that are high compared to sampling costs	Random sampling and composite sampling	Produce an equally precise (or more precise) estimate of the prevalence with fewer analyses and lower cost
Attempting to identify population units that have a rare trait (for a finite population of units)	The ability to physically mix aliquots from the samples and then retest additional aliquots	Composite sampling and retesting	Classify all units at reduced cost by not analyzing every unit
Attempting to identify population unit(s) that have the highest contaminant levels (for a finite population of units)	The ability to physically mix aliquots from the samples and then retest additional aliquots	Composite sampling and retesting	Identify such units at reduced cost by not analyzing every unit

[a]Adapted from Table 3-1 from EPA QA/G-5S, Guidance on Choosing a Sampling Design for Environmental Data Collection (Dec 2002)

Table 27. Project Quality Control Checks[a]

QC Check	Information Provided
Blanks	
Field Blank	Transport, storage, and field handling bias
Reagent Blank	Contaminated reagent
Rinsate or Equipment Blank	Contaminated equipment
Method Blank	Response of an entire laboratory analytical system
Replicates, Splits, etc.	
Field Collocated Samples	Sampling + measurement precision
Field Replicates	Precision of all steps after acquisition
Field Splits	Shipping + interlaboratory precision
Laboratory Splits	Interlaboratory precision
Laboratory Replicates	Analytical precision
Analysis Replicates	Instrument precision

[a]Adapted from Table 5, EPA QA/G-5, Guidance for Quality Assurance Project Plans (Dec 2002)

- *Trip Blanks*. Trip blanks (also known as FRB, field reagent blanks) are provided by the lab as required and must be included when the samples are returned. **Note:** Trip blanks ***must never*** be opened and ***must always*** be kept with the samples. Trip blanks are required to identify possible interferences associated with the shipping, collection, and storage of samples. Trip blanks must be handled along with each sample set, which is composed of the samples collected from the same general sample site at approximately the same time. Trip blank sample bottles are filled with reagent water, sealed, and shipped to the sampling site with the empty sample bottles. Trip blanks must remain sealed until analysis and must be shipped back to the laboratory with the filled sample bottles. Preservatives must not be added to the trip blanks due to the potential for preservative decomposition when sampling kits are stored under deployment conditions.
- *Equipment Blanks*. Equipment blanks (also known as rinsate blanks) ***must*** be collected like a regular sample, but without adding the preservatives. The equipment blank is a reagent grade aqueous or organic solution that is as free of analyte as possible and is transported to the site, opened in the field, poured over or through the sample collection device, collected in a sample container, and shipped to the laboratory. This serves as a check on sampling device cleanliness and will be affected by the site and sample handling conditions. This type of blank will be analyzed in the laboratory just like any other sample.
- *Temperature Blanks*. Temperature blanks are containers of water that are shipped along with the samples en route to the laboratory. The laboratory will measure the temperature of the blank upon receipt. This is used to verify that samples are maintained at less than 4 °C, which is necessary with for many analytical methods.
- *Duplicate Samples*. Duplicate samples are intended to identify variability in the analytical results associated with field and laboratory methods and the inherent heterogeneity of the media. Samples are taken at the same location employing the same collection methods.
- *Split Samples*. Split samples are often used to identify variability between sample handling methods or between laboratories. The sample material is homogenized in the field and placed into two separate sample containers for submittal to two separate labs.

3.8 Implementation: Selecting Equipment and Conducting Sampling

3.8.1 ***Sampling Equipment.*** The tools, devices, and methods used for sampling contaminants will vary with the form, consistency, and location of the matrix to be sampled. The following sections provide a brief summary of types of sampler devices available for air, water, and soil. These are by no means an inclusive list of all commercially available sampling equipment; rather, they are a brief summary of possible options. For a detailed discussion on selecting a suitable sampling device, refer to ASTM Standard D 6232, *Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection*. Equipment selection criteria should include consideration for:

- Chemical compatibility
- Physical compatibility
- Sample volume capability
- Ease of operation
- Ability to be decontaminated
- Single use or reusable
- Cost

3.8.2 ***Sample Preservation.*** Sample preservation methods and maximum holding times associated with different analyses need to be taken into consideration to ensure proper analysis. Preservation of the samples is accomplished by pH control, chemical addition, temperature control, or a combination of the above methods. Preservation of the samples may be required if immediate analysis of the sample is not possible. When using chemical additive for preservation, invert the container several times after filling to ensure adequate mixing of the preservative with the sample. The preservation methods and recommended sample holding time should be checked before sampling for any analyte.

In most cases, sampling containers already containing the required preservative can be supplied by the lab. *Do not rinse* these containers prior to filling, and do not allow overflowing. With some sampling containers, there are preservatives that ***must*** be added to the sampling container ***after*** the sample has been collected. The preservative will be provided by the lab in a separate vial or container with the sample container. Please ensure the correct sequence of sampling and preservation is followed.

3.8.3 ***Holding Times.*** The maximum holding times are established by the published method. These holding times are based on the use of recommended sample containers and preservation techniques. Please contact the lab before shipping samples if the lab will receive the samples with less than 48 hours to meet holding times.

3.8.4 ***Sample Storage.*** In general, the shorter the time that elapses between collection of samples and its analysis, the more reliable the analytical results. Remember to adhere to particular parameter storage requirements; typically, most samples require storage at 4 °C.

3.9 Drinking Water Sampling

Installation BEs are responsible for funding and executing routine drinking water compliance sampling as directed by AFI 48-144, *Drinking Water Surveillance Program.* Base-specific monitoring frequencies, analytical methods, and laboratories should be documented in detail in the local Sampling, Analysis, and Monitoring (SAM) plan. The regulatory agency ***must*** certify a laboratory before it may analyze drinking water samples for compliance monitoring. Local contracting mechanisms and funds should be used to obtain analytical services of a certified lab. In the event a local contract is not established, the USAFSAM commercial lab BPA may be

available. The commercial labs utilized by USAFSAM are certified in most states on many fields of testing. Contact Customer Service if your base is unable to establish a local contract and requires the use of the USAFSAM commercial lab BPA for emergent sampling requirements.

General drinking water sampling guidance is provided in the sections below. Refer to the base-specific SAM plan and the USAFSAM report Drinking Water Surveillance Technical Guide for additional details regarding drinking water sampling and analysis.

3.9.1 Drinking Water General Sample Collection Considerations. It is important that good sampling techniques be followed to ensure representative samples are sent to the laboratory for analysis. Proper selection, collection, identification, and shipment of samples must occur to ensure the reliability of all Air Force drinking water programs.

Example Sampling Procedures. The following are examples of common utility sampling locations and some of the basic nuances to sampling these locations.

- *Sampling from Accessible Water Taps:* Remove the aerator, if present; aeration will remove volatile organic compounds (VOCs) from the sample. Maintain a steady flow of water until the water temperature is constant, and then hold the sample container under the discharge at an angle so that the sample flows down the inside wall of the sample container. This also minimizes aeration. Fill the container(s) to the fill line (if present) or to the top of the container lip.
- *Sampling from Fire Hydrants:* Sampling from a hydrant is usually not recommended but may be required in the event of a water main break or repair. If sampling at a hydrant is required, remove the small cap from the low-pressure side, adjust the flow down to a manageable level for sample collection, and collect the sample as if from a tap.
- *Sampling from Water Towers:* Sampling from a water tower is usually only required in rare situations and possibly during water contingency monitoring to establish baseline characteristics. If sampling is required, allow the water to run for at least 20 to 30 minutes to clear the plumbing leading to the sample port before sampling.

3.9.2 Drinking Water Analytical Methods. As mentioned previously, sampling and analytical regulatory requirements should be thoroughly documented in the SAM plan. A few common SDWA analytical methods are listed in Table 28 that, in addition to regulatory compliance, may be used as a screening method in conjunction with a general health risk assessment or an OEHSA. Check with the lab for container and preservative requirements and analytical method(s) to be used prior to sampling. In addition, sampling interferences, laboratory methods, and known matrix effects may require specific project preservations to be developed. A sampling plan should be prepared and reviewed with the laboratory prior to starting any sampling operation.

3.10 Surface and Ground Water Sampling

If a complete exposure pathway is present, it may be necessary to sample surface, ground, and/or storm water. Assess these water sources from a health perspective, e.g., *"Is storm water run-off a potential source of OEH threats due to industrial operations and does it affect personnel in the AOC?"*

Table 28. General Drinking Water Analytical Methods

Contaminant	Method	Container	Comments
VOCs	EPA 524.3	Amber vial, Teflon-lined septum	Recommended container size is 40- to 120-mL glass vial with PTFE-faced silicon septum, preserve with hydrochloric acid (HCl) to pH<2, cool to 4 °C, no headspace. If chlorine is present, add ascorbic acid prior to HCl addition. Hold time is 14 days.
Semi-VOCs	EPA 525.2	Amber vial, Teflon-lined septum	Recommended container size is 1-L amber bottle, reduce residual chlorine by adding sodium sulfite, preserve with HCl to pH<2, cool to 4 °C, no headspace.
Anions	EPA 300.1	Plastic or glass jar	Recommended container size is 100 mL, cool to 4 °C. Hold time is 28 days.
Metals	EPA 200.7 EPA 200.8	Plastic or glass jar	Recommended container size is 500 mL, preserve with nitric acid (HNO_3) to pH<2, cool to 4 °C. Preserved samples are stable for 6 months. For determination of dissolved metals, samples should be filtered on-site prior to preservation with HNO_3. If not possible, samples need to get to the lab as soon as possible for filtering. Indicate on paperwork whether or not samples were field-filtered.
Pesticides			Recommended container size is two 1-L glass bottles.
Organophosphorus	EPA 507	Glass jar	Residual chlorine should be reduced by adding 50 mg/L of sodium sulfite. Adjust pH<2 by adding HCl, cool to 4 °C. Hold time is 14 days.
Organochlorine	EPA 508	Glass jar	Recommended container size is two 1-L glass bottles. Residual chlorine should be reduced by adding 50 mg/L of sodium sulfite. Adjust pH<2 by adding HCl, cool to 4 °C. Hold time is 14 days.

Additional drinking water methods can be obtained by visiting the EPA Drinking Water Analytical Methods website.

3.10.1 Surface and Ground Water General Sampling Considerations

Surface water sampling can include any body of water that rests or flows over land, including streams, rivers, lakes, ponds, creeks, lagoons, estuaries, surface impoundments, or coastal waters. Samples can be collected at surface level or at a prescribed depth interval. Sampling points should be established at the locations where distinct changes in pH, temperature, depleted oxygen, or conductivity indicate the possible presence of contaminants. When sampling for a nonpoint pollution source, it is important to consider special properties and precautions when developing a representative sampling design, including stratification, current, storm events, time of year, circulation, velocity, turbidity, and salinity.

Actual sampling situations encountered in the field may vary according to the site. The most important goal of surface water sampling is to collect a representative sample of the appropriate horizons or phases present in the liquid that meets the DQOs. Surface water can be collected as a grab or as a composite sample. Samples that require analysis for volatile organic analysis (VOA) should be submitted to the laboratory as a grab sample rather than a composite sample to minimize the potential loss of the volatile contaminant.

Ground water monitoring wells, underground injection wells, and industrial wells are potential sources of ground water samples. Evacuation or purging of the water column in a monitoring well is required prior to sample collection to remove the standing water column and induce ground water flow from the surrounding formation into the well.

3.10.2 Surface and Ground Water Sampling Equipment. Surface and ground water sampling equipment includes, but is not limited to, laboratory-cleaned sample bottles, automatic samplers, bacon bombs, weighted bottle sampler, bailers, dippers or "pond samplers," drum thief, Kemmerer sampler, submersible pumps, peristaltic pumps, piston pumps, and liquid grab samplers. Decontamination of existing and new equipment is required prior to use in the field. Table 29 summarizes possible liquid sampling equipment options. The table also provides the name of additional guidance documents that can be referenced for detailed instructions on equipment use. Consider the following factors when selecting a sampling device:

Surface Water

- Will the sample be collected from shore or from a boat?
- From what depth should the sample be collected?
- What is the overall depth and flow direction of the river or stream?

Ground Water

- Type of well and depth of well
- Diameter of well casing
- Expected recharge rate of well

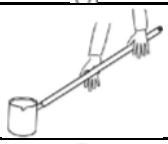
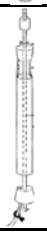
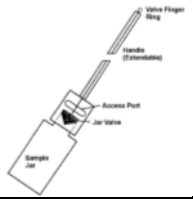
3.10.3 Surface and Ground Water Analytical Methods. Table 30 lists common analytical methods applicable to surface and ground water sampling. In-garrison, the installation NPDES permit will list specific sampling and analytical monitoring requirements including frequency, sample location, sampling method, and QC requirements. While the NPDES compliance sampling requirements are managed by Civil Engineering, this is a good place to start if no information is known about potential surface water contamination.

3.11 Soil Sampling

Soil samples are collected for a variety of reasons including chemical, physical, toxicological, and biological analysis. Due to the inherent variability of soils, collection techniques should be evaluated and chosen for each sampling site and each sampling purpose. Choosing the most appropriate sampling device and technique depends on the (1) purpose of the sampling, (2) location of the soil, and (3) characteristics of the soil.

3.11.1 General Soil Sampling Considerations. Both sample depth and area are considerations in determining appropriate sample volume. Depending on the analytes being investigated, samples are collected at the surface (0-3 inches), extended surface (0-6 inches), and/or at 1-foot depth intervals. Nonwater soluble contaminants such as dioxin and PCBs are often encountered within the first 6 inches of soil. Water-soluble contaminants such as metals, acids, ketones, and alcohols will be encountered at deeper depths in most soils except clays. Contaminants in solution, such as pentachlorophenols in diesel fuel and pesticides in solvents, can penetrate to great depths (e.g., down to bedrock), depending on soil type. The following is a description of the types of samples that may be collected:

Table 29. Liquid Sampling Equipment Selection Guide[a]

Matrix	Sampling Device	Image	Device-Specific Guidance	Sample Type	Comments
Liquids	Automatic sampler		ASTM D 6538 EISOPQA Manual (USEPA 1996b)	Shallow (25-in.), discrete or composite	Auto samplers are available to collect samples for VOA, provide a grab or composite sample, and may be unattended. Need power source/battery. Commonly used at waste water treatment plants. Must be knowledgeable of compatibility of waste and sampler components.
	Bacon bomb		USEPA 1984 USEPA 1994c	Depth, discrete	For parameters that do not require a PTFE sampler. Recommended for sampling of lakes, ponds, large tanks, or lagoons. May be difficult to decontaminate and materials of construction may not be compatible with sample matrix.
	Bailer		ASTM D 4448 USEPA 1992c USEPA 1994c	Depth, discrete	Bailers are not recommended for sampling ground water for trace constituent analysis due to sampling induced turbidity (USEPA 1992c and Puls and Barcelona 1996). Unable to collect samples from specific depths (unless a point-source bailer is used). Available in a variety of sizes as either reusable or single-use devices. May be chemically incompatible with certain matrices unless constructed of resistant material.
	COLIWASA		ASTM D 5495 ASTM D 5743 ASTM D 6063 USEPA 1980	Shallow, composite	Reusable and single-use models available. Inexpensive. Glass-type devices may be difficult to decontaminate. Collects undisturbed sample. For mixed solid/liquid media will collect semi-liquid only. Not for high viscosity liquids.
	Dipper (or "pond sampler")		ASTM D 5358 ASTM D 5013 USEPA 1980	Shallow, composite	For sampling liquids in surface impoundments. Inexpensive. Not appropriate for sampling stratified waste if discrete characterization needed.
	Drum thief		ASTM D 6063 ASTM D 5743 USEPA 1994b	Shallow, composite	Usually single use. If made of glass and reused, decontamination may be difficult. Limited by length of sampler, small volume of sample collected, and viscosity of fluids.
	Kemmerer sampler			Depth, discrete	Recommended for lakes, ponds, large tanks, or lagoons. May be difficult to decontaminate. Materials may not be compatible with sample matrix, but all-PTFE construction is available. Sample container exposed to media at other depths while being lowered to sample point.
	Liquid grab sampler			Shallow, discrete, composite-suspended solids only	For sampling liquids or slurries. Can be capped and used to transport sample. Easy to use. May be lowered to specific depths. Compatibility with sample parameters is a concern.

[a]Images and table adapted from Table 9, EPA 530-D-02-002, RCRA Waste Sampling Draft Technical Guide

Table 30. Surface and Ground Water Analytical Methods

Contaminant	Method	Container	Comments
VOC Screen	EPA SW 8260	Glass vial, Teflon-lined septum	Recommended container size is 40 mL (2), preserve with HCl to pH<2, cool to 4 °C, no headspace. Two vials per sample.
Metals	EPA SW6010 EPA SW6020	Plastic or glass jar	Recommended container size is 500 mL, preserve with HNO_3 to pH<2, cool to 4 °C. Preserved samples are stable for 6 months.
Pesticides			
Organophosphorus Pesticides	EPA SW8141	Amber glass, Teflon-lined cap	Recommended container size is two 1-L samples. Hold time is 7 days, cool to 4 °C.
Organochlorine Pesticides	EPA SW8081/8082	Amber glass, Teflon-lined cap	Recommended container size is two 1-L samples. Hold time is 7 days, cool to 4 °C.

- *Cores* are vertical discrete grab samples. Most appropriate for historical contamination information or dredging decisions at heavily contaminated areas.
- *Scoops and Dredges* are surface (top 2 to 4 cm) sediment grab samples. Most appropriate for benthic, sediment oxygen demand (in-situ), recent ambient conditions, and recent contaminant investigation.
- *Scoops and Dredge Composites* are surface sediment composite samples. May be used to reduce costs for specific conditions/situations such as ambient or specific historical data. In general, however, discrete sampling is preferred if resources are available.

3.11.2 Soil Sampling Equipment. Soil sampling devices should be of sufficient quality not to contribute contamination to samples (i.e., painted surfaces that could chip off into the sample). Additionally, the sampling equipment should be either easily decontaminated or cost effective if considered to be single use only. Soil sampling equipment includes, but is not limited to, augers, core samplers, dredges, scoops, shovels, trowels, split barrel samplers, and triers. Table 31 summarizes possible soil sampling equipment options. The table also provides the name of additional guidance documents that can be referenced for detailed instructions on equipment use.

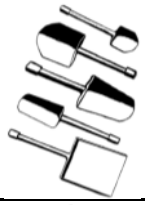
3.11.3 Soil Sampling Analytical Methods. Table 32 lists common analytical methods that may be beneficial if laboratory analysis of soil is required in conjunction with a health risk assessment.

3.12 Air Sampling

Environmental air sampling methods are typically categorized by the air or emission source or by the type of pollutant measured. A few of these categories include indoor air samples, ambient air samples, stationary source samples, and soil vapor samples.

- *Indoor air sampling* is conducted in all types of living and workplace environments, including industrial facilities, office buildings, and homes. OSHA, NIOSH, and EPA methods are typically referenced for collecting indoor air samples.

Table 31. Soil Sampling Equipment Selection Guide[a]

Matrix	Sampling Device	Image	Device-Specific Guidance	Sample Type	Comments
Soils	Auger		ASTM D 1452 ASTM D 4700 ASTM D 6063 Mason 1992 USEPA 1993c	Surface or depth, disturbed	Easy and quick for shallow subsurface samples but not recommended for VOAs. Requires considerable strength and labor and destroys soil horizons.
	Miniature core sampler		ASTM D 4547 ASTM D 6418	Discrete	Used to retrieve samples from surface soil, trench walls, or subsamples from soil cores. O-rings on plunger and cap minimize loss of volatiles and allow device to be used to transport sample. Designed for single use. Cannot be used on gravel or rocky soils. Must avoid trapping air with samples.
	Ponar dredge		ASTM D 4387 ASTM D 4342 USEPA 1994e	Bottom surface, rocky or soft, disturbed	One of the most effective samplers for general use on all types of substrates (silt to granular material). May be difficult to repeatedly collect representative samples. May be heavy.
	Scoop, shovel, and trowel		ASTM D 5633 ASTM D 4700 ASTM D 6063	Surface, disturbed, selective	Usually for surface soil and solid waste samples. Available in different materials and simple to obtain. Easy to decontaminate and rugged. May bias sample because of particle size. May exacerbate loss of VOCs.
	Split barrel sampler		ASTM D 1586 ASTM D 4700 ASTM D 6063	Discrete, undisturbed	May be driven manually or mechanically by a drill rig with trained personnel. May collect a sample at depth. A liner may be used in the device to minimize disturbance or for samples requiring VOAs.
	Trier		ASTM D 5451 ASTM D 6063	Surface, relatively undisturbed, selective	Recommended for powdered or granular materials, wastes in piles or in bags, drums, or similar containers. Best for moist or sticky materials. Will introduce sampling bias when used to sample coarse-grained materials.
	Thin-walled tube		ASTM D 1587 ASTM D 4823 ASTM D 4700	Surface or depth, undisturbed	Useful for collecting an undisturbed sample (depends on extension). May require a catcher to retain soil samples. Inexpensive, easy to decontaminate. Samples for VOAs may be biased when sample is extruded.

[a]Images and table adapted from Table 9, EPA 530-D-02-002, RCRA Waste Sampling Draft Technical Guide

Table 32. Soil Sampling Analytical Methods

Contaminant	Method	Container	Comments
VOC Screen	EPA SW8260	Glass, Teflon-lined cap	Recommended container size is 125 mL, cool sample to 4 °C, sample hold time is 14 days.
Metals	EPA SW6010 EPA SW6020	Plastic or glass jar	Samples are stable for 6 months, keep samples cool to 4 °C, recommended container size is 125 mL.
Pesticides			
Organophosphorus Pesticides	EPA SW8141	Glass, Teflon-lined cap	Recommended container size is 250 mL, cool sample to 4 °C, hold time is 7 days.
Organochlorine Pesticides	EPA SW8081/8082	Glass, Teflon-lined cap	Recommended container size is 250 mL, cool sample to 4 °C, hold time is 14 days.

- *Ambient air sampling* is conducted in outdoor locations, usually in the vicinity of known or suspected sources of air pollutants at ambient temperature, pressure, and humidity. Typical locations for ambient air sampling include soil remediation sites and manufacturing facilities. Ambient air sampling can also be conducted to assess nuisance particulate sources, spreading over a large geographical region such as automotive traffic on a highway or the air quality of a city.
- *Stationary source sampling* is also mainly conducted outdoors, but may also occur at indoor locations in industrial settings. Stationary source samples are collected from a single point source of emissions, such as an exhaust stack. Typical locations for source testing include industrial boilers, various manufacturing facilities, and power plants. Regulatory agencies that have developed methods or guidelines for ambient and stationary source testing include EPA, California Air Resources Board, Department of Toxic Substances Control, and various Air Quality Management Districts.
- *Soil vapor samples* may be used for investigations of possible soil and ground water contamination. Analysis of these whole air samples can occur both in the field and using reachback laboratories. Since analytical methods have yet to be published specifically for soil vapor, ambient air methods are typically used.

Air pollutants are categorized by the regulations controlling them and their chemical and physical properties. National air standards divide air pollutants into two categories: criteria pollutants and hazardous air pollutants.

3.12.1 Criteria Pollutants. The NAAQS list six criteria pollutants with established national regulatory limits including nitrogen dioxide, sulfur dioxide, CO, Pb, ozone, and PM. PM is further defined by EPA as total suspended particulates (TSPs), $PM_{2.5}$, and PM_{10}. Note: these definitions differ from the ACGIH® respirable, thoracic, and inhalable fractions.

- *TSPs*, total suspended particulates, are suspended matter in air including solid and low vapor pressure liquid particles. TSPs account for all suspended particulates, with no preference to size selection. The size range is typically 0.01 µm to 100 µm and larger.
- *PM_{10}* are particles with a diameter less than 10 µm; they pose a health risk because they can be inhaled and accumulate in the respiratory system. Particles with diameters between 2.5 and 10 µm are referred to as "coarse." Sources of coarse particles include crushing or grinding operations and dust from paved or unpaved roads.

- $\underline{PM_{2.5}}$ are particles with a diameter less than 2.5 µm that are referred to as "fine" particles. They are believed to pose the largest health risk. Because of their small size, fine particles can lodge deeply into the lungs. Sources of fine particulates include all types of combustion and some industrial processes.

3.12.2 Hazardous Air Pollutants. HAPs, some of which have national, state, or local regulatory limits, include 187 compounds. HAPs, which are usually collected using whole air sampling, can be divided into the following categories based on their chemical composition and physical properties:

- Nonvolatiles (metals and heavy organics, etc.) Boiling Point > 300 °C
- Semi-volatile organic compounds (SVOCs) Boiling Point 120-300 °C
- VOCs Boiling Point <120 °C

3.12.3 General Air Sampling Considerations.

Particulates. Air sampling for particulates typically involves capturing the particles on filters using either a high-volume or low-volume sampling pump. The mass of particles on the filter is then determined. The filter can be furthered analyzed for specific analytes if desired (e.g., Pb, chromates, etc.).

Nonvolatiles and SVOCs. Air sampling for nonvolatiles and most SVOCs usually involves trapping the compounds on solid (charcoal tubes), liquid media (impingers), or filters, then extracting or desorbing the media for analysis. Refer to the occupational health section of this guide for additional information on sampling with solid sorbent material and filters.

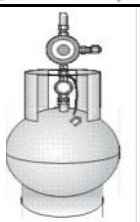
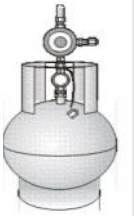
VOCs. VOCs may be collected on solid sorbent material or by conducting whole air sampling. Whole air sampling, in which samples are collected and analyzed in the gaseous phase, is best suited for volatile, nonpolar compounds and fixed gases. Some SVOCs with boiling points as high as 170 °C can be collected using whole air sampling, depending on the temperature and reactivity of the sample matrix and the sampling media.

3.12.4 Air Sampling Equipment. The two most commonly used media for whole air sampling are metal canisters and bag samples (Table 33).

Metal Canisters. Stainless steel canisters, made less reactive by depositing a pure chrome-nickel oxide on the interior surface, are popular for whole air sampling. The Summa® canister is a common (but trademarked) term used to refer to an air sampling canister. Air sampling canisters may also be referred to as a SilcoCan™ or MiniCan®. Canisters are generally referred to as a part per billion sampling device. Canisters come in a variety of sizes including 400 cc, 1 liter, and 6 liters. These metal canisters use passive sampling, in which a vacuum is used to draw air into a stainless steel canister. The canisters can be used to collect TO-15 analytes, as well as fixed gases like methane, CO, carbon dioxide, oxygen, and nitrogen. The canisters are cleaned and analyzed for cleanliness prior to use, and may be cleaned and reused many times. Holding times for most analytes in Summa canisters have shown to be stable for up to 30 days. Canisters can be taken as a grab sample (< 5 minutes) or as an integrated sample (taken over a longer period of time, usually 30 minutes to 24 hours). Integrated sampling using a canister requires a flow controller to regulate the rate at which the sample enters the sampling container.

Canisters are completely evacuated prior to use. During sampling, a valve is opened and air is drawn into the canister through the inlet until the canister pressure has equilibrated with that of the source being sampled. The vacuum/pressure gauge is used to monitor the canister pressure and indicates when there is an air flow problem or when sampling is complete. Canister rentals are available through USAFSAM contract labs. Contact Customer Service to arrange shipment.

Table 33. Air Sampling Equipment Selection Guide

Matrix	Sampling Device	Image	Device-Specific Guidance	Sample Type	Comments
Air	Sorbent Tube		EPA TO-17	Active sorbent tube sampling	Used for the determination of VOCs in ambient air using active sampling onto sorbent tubes.
	Summa® Canister		EPA TO-15 EPA TO-14A	Whole air VOC samples	Stainless steel vacuum canister. Rugged and does not require the use of a pump.
	Fused Silica-Lined Summa® Canisters		EPA TO-15 EPA TO-14A	Whole air reactive organic compounds	These canisters have been treated with an inert silica glass lining that extends holding times for polar or oxygenated compounds and sulfur-containing compounds.
	Gas Bags		EPA TO-15 EPA TO-14A	Whole air VOC samples	Two layers of film sealed at the edges with a valve on one side. Sample will require special handling (fragile) and a pump for collection.
	Particulate Sampling Systems		Manufacturer's guidance	Filter	Refer to manufacturer's guidance for use of federal reference samplers and other particulate sampling systems (Deployable Particulate Sampler (DPS) Sampling Kit shown to the left). Filters should be preweighed prior to sampling.

Bag Samples. Flexible bags for the collection of whole air samples are available in several different plastic materials including Tedlar®, Teflon®, Mylar®, etc. Sample bags consist of two layers of film sealed together at the edges with a sampling valve on one side. Sample bags are generally referred to as a ppm sampling device. Care should be taken when sampling for trace contaminants, since VOCs may be present in sampling bags in ppb concentrations. Conditioning bags prior to use by purging with nitrogen further reduces contaminants. Once a sample bag has been used, however, it cannot be reused for low concentration (sub-ppm) sampling because the sample bag may absorb VOCs, which can off-gas at a later time. Sample bags come in a variety of sizes from >1 liter to 30 liters. The holding time for most compounds in sample bags varies depending on the compound, but is significantly less for canisters: typically 1 day or less for sulfur compounds and 3 days for other compounds. Sample bags are less expensive and easy to handle and transport, but require the use of a pump, have a short hold time, and are fragile.

Proper sample bag material selection depends on matching the particular film characteristics with the compound to be sampled, the concentration level, and the time between sample collection and analysis. Currently Tedlar® bags are the most commonly used bags in the Air Force; however, in 2009, DuPont announced its plan to phase out support for Tedlar® film in the sample bag market. The Kynar® bag is one alternative if Tedlar® bags become unavailable. Kynar® bags have low VOC and sulfur background. Contact Customer Service if you require assistance selecting the appropriate sampling bag for your unique situation.

3.12.5 Air Sampling Analytical Methods. Table 34 lists popular analytical methods that may be beneficial if laboratory analysis of air samples is required in conjunction with a health risk assessment.

3.13 Identification of Unknown Materials

The USAFSAM contract labs are capable of performing qualitative material characterizations of unknown bulk solid materials using the methods indicated in Table 35. To ensure quality data to support identification, it is extremely important to provide as much information as possible when submitting samples. Examples include shipping documentation, container labels, MSDS, communication memos, or historical documents. Also helpful is information regarding the location, including type of industrial activity, types of machinery, or other materials located at the scene. USAFSAM is ***not*** capable of handling unknown samples suspected of containing chemical warfare, biological agents, or explosives.

3.14 Occupational and Environmental Health Site Assessments

The *Occupational and Environmental Health Site Assessment (OEHSA) Documentation and Data Management Technical Guide* available on the ESOH Service Center outlines general sampling considerations in Chapter 7. The tables provided in the tech guide are *simply guidance* on sampling tools and techniques to characterize the background or baseline levels; this guidance ***must*** be adjusted as appropriate to accommodate local conditions. OEHSA sampling requirements can span the spectrum of environmental sampling possibilities, crossing mediums (i.e., air, water, soil) requiring varying analytical methods (e.g., EPA, ASTM, NIOSH). In most cases, OEHSA sampling generally will start with direct reading instruments. When the determination to conduct lab sampling is made, a decision to the appropriate analytical method must be made. When the analyte and media are known, an analyte-specific method should be chosen. If no information or limited information is known about an AOC, the general screening

sampling methods for soil, surface water, drinking water, and air as discussed in the previous sections of this guide may be useful as a starting point for the environmental HRA.

Table 34. Air Sampling Analytical Methods

Contaminant	Method	Media	Comments
VOC Screen	EPA TO-17	Triple-bed tube (Supelco Carbotrap®)	Keep samples cold. Tubes must be ordered from the lab and must be used within 30 days.
	EPA TO-15	Summa® canister or Tedlar® bag	Keep samples cold. Summa canister hold time is 30 days, Tedlar bag is 3 days. 6-L Summa canisters are recommended for lower concentration samples (ambient air) and 1-L Summa canisters for higher concentration samples (soil gas, flares, etc.). Summa canister rentals may be coordinated by calling Customer Service.
$PM_{2.5}$ **PM_{10}** **TSP**	EPA Method IO-2	Various filters	Recommended when a Federal reference method is required. Filters must be preweighed within 30 days of the sampling period. Refer to system manufacturer's operating instructions for sampling details.
	SKC DPS Kit AirMetrics TAS AirMetrics MiniVol	Various 47-mm filters	The DPS, AirMetrics TAS, and AirMetrics MiniVol are not Federal reference samplers. Filters must be preweighed prior to sampling. Refer to system manufacturer's operating instructions for sampling details. *Note: Particle air samplers may be coming through the career field modernization effort; alternatively, they may be available through equipment request to USAFSAM or USAPHC*
Metals	Modified NIOSH 7300 EPA Method IO-3	25-mm MCE filter Various 47-mm filters	A variety of methods including ICP-OES and ICP-MS may be used to determine chemical species, may be used in conjunction with PM monitoring.
Asbestos	TEM by EPA Level I-III ISO 10312 AHERA TEM ASTM D-6281-96 TEM		TEM method divided into three levels of analysis. Level I is morphology and visual selected area electron diffraction (SAED) pattern recognition, Level II adds elemental analysis, and Level III adds some zone axis SAED and elemental analysis Ambient air determination of asbestos fibers, direct transfer TEM method. Sampled with elutriator or direct air sampling. Normally used for building clearance, additional grid openings for sensitivity ASTM version of ISO 10312

Table 35. Identification of Unknown Materials

Contaminant	Method	Container	Comments
Unknown Bulk Material Characterization	PLM/MC	Wide mouth glass jar	Polarized Light Microscopy/Materials Characterization (PLM/MC). Uses optical properties to identify larger particles.
	TEM/MC	Wide mouth glass jar	Transmission Electron Microscopy/Materials Characterization (TEM/MC). Morphology, selected area electron diffraction (SAED) and energy dispersive spectroscopy (EDS). Uses elemental chemistry and crystallinity to identify very small particles – less than 10 µm.
	SEM/MC	Wide mouth glass jar	Scanning Electron Microscopy/Materials Characterization (SEM/MC). Uses morphology and elemental chemistry to identify larger particles from dusts or bulks.
	SEM/EDS	Wide mouth glass jar	Scanning Electron Microscopy/Electron Dispersive Spectroscopy (SEM/EDS). Uses elemental analysis of individual particles to provide qualitative and as well as quantitative results as desired.

3.15 Statistics and the Data Quality Assessment (DQA)

As defined by the EPA, a Data Quality Assessment (DQA) is the scientific and statistical evaluation of environmental data to determine if they meet the planning objectives of the project, and thus are the right type, quality, and quantity to support their intended use. Summarizing environmental data and choosing the right statistical method are a large task, and one that is currently not supported in DOEHRS for environmental sampling. For detailed guidance on performing a DQA for environmental sample results, refer to the EPA document *Data Quality Assessment: Statistical Methods for Practitioners (EPA QA/G-9S)*. By using DQA, a reviewer can answer four important questions:

1. Can a decision (or estimate) be made with the desired level of certainty, given the quality of the data?
2. How well did the sampling plan perform?
3. If the sampling strategy is used again for a similar study, would the data be expected to support the same intended use with the desired level of certainty (i.e., is there repeatability)?
4. Is it likely that sufficient samples were taken to enable the reviewer to see an effect was really present?

SECTION 4: RADIATION

4.0 Radioanalytical Services

There are multiple reasons why a radiological sample may be collected for laboratory analysis. It is critical that the BE have a clear understanding of the purpose of a sample. This information must then be effectively communicated to the lab so that they can ensure a proper analysis is performed and that the results meet the needs of the customer. Once the customer receives the results, they must then be able to effectively interpret the results. If any part of this process is not carried out effectively, then both time and resources are wasted.

This section of the guide serves as an update to the former USAFSAM/OEHHL *Radioanalyses Laboratory Sample Guide Version 3.0*, dated 22 January 2009. Analytical Services has a wide range of in-house radioanalytical capabilities at the Wright-Patterson AFB laboratory shown in Table 36.

Table 36. USAFSAM/OEA Radioanalytical Capabilities

Radioanalytical Capabilities
Gamma Spectroscopy
Alpha Spectroscopy
Gross Alpha/Gross Beta Counting
Liquid Scintillation Counting (LSC)
Inductively Coupled Plasma Mass Spectroscopy (ICP-MS)

4.1 Significant Changes from Previous Edition

The following are significant changes from the 2009 edition of the sampling guide and important tips to remember:

- *Swipes.* It is now recommended that swipe samples should be taken wet by adding a few drops of deionized water (DI) to dampen the swipe/swab. Previously, guidance was given that swipe samples should be taken using a dry swipe. Recent studies have demonstrated that this results in a very low collection efficiency of removable activity, as low as 10%. It has been shown that wet swipes have a much higher efficiency of up to 90%. Thus, to obtain more representative samples, wet swipes are now recommended.
- *Field Blanks*. A field blank is now required to be submitted for each batch of samples. Previous editions have not required the submission of field blanks for all samples. A field blank consists of sample media that is treated exactly the same as the sampled media but is free of any contamination. For example, a field blank for a wipe can be accomplished by swiping a clean surface and submitting it with any group of swipes. If a field blank is not possible, then note this on AF Form 2753. Field blanks allow the lab to give you more accurate results.
- *Sample Submission Forms*. It is critical that the submission forms accompanying samples be completed correctly and completely. Historically, the lab has received an unacceptable number of samples that did not have proper paperwork or had analysis requests that were either incomplete or incorrect. Tips to remember include:

- "All" is not an analysis method. Be specific with analysis and nuclide, if known.
- The Radioanalytical Lab cannot analyze for noble gases, e.g., Kr-85. Special media is required.
- Include complete sender information including base code, base sample number, DSN, etc. Also include an alternate contact who can answer questions about the sample if the primary is not available.
- It is highly recommended for any bioassay analysis including baseline samples that you contact Customer Service for guidance. The lab will assist you in determining the analysis needed.

Incomplete or incorrect information will delay your sample results and can result in useless information. If at any time you have any question about how to sample and what to sample for, please contact Customer Service (CS). The lab will make every attempt to contact the base for missing information or to correct errors. If CS does not receive a timely reply, a memo will be sent through the major command BE for investigation.

4.2 Radiation Sample Plan Development

There are multiple steps in accomplishing successful sampling. First, the need or driver for laboratory sampling must be identified. This can be driven by a regulatory requirement or by the need for data. For example, an unknown source is found and requires identification before it can be properly disposed. At this point the number of samples needed and their locations should be identified. Figure 25 below outlines the radiation sample planning processes. Three key steps in the process are determining the action level, selecting the type of analysis, and interpreting the results. Interpreting results is outside the scope of this guide. Contact CS if you require assistance in interpreting USAFSAM/OEA results.

- *Action Level.* Before a sample is submitted, there should be an AL associated with each sample. An AL is the point at which a sample result will initiate some action being taken or some level of concern or risk being identified. Not all samples require an AL; some samples may only be a measure of risk.

- *Type of Analysis*. Next the type of analysis to be performed must be determined. The analysis performed must be sensitive enough to comply with any regulatory requirements or to identify an associated risk to a satisfactory level.

- *Results Interpretation*. Lastly, the results of the analysis must be compared to an AL and interpreted by the requesting customer.

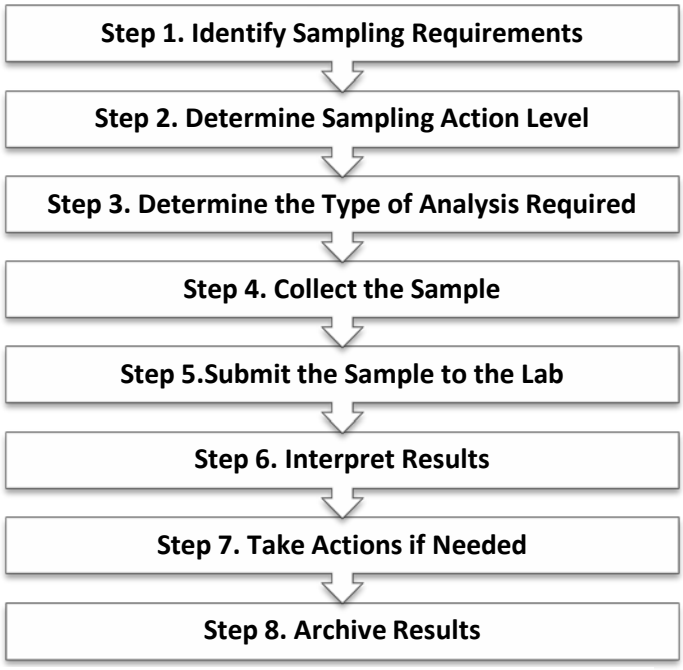


Figure 25. The Complete Radiological Sample Collection Process

4.3 Identifying Sampling Requirements and Action Levels

The first step in the sample process is determining the need to sample and the requirements associated with the sample. There are numerous reasons for collecting a radiological sample. Some of the most common reasons in the AF include permit compliance, hazard assessment, contamination identification, waste disposal/characterization, shipping requirements, and exposure monitoring. It is important that the reason for the sample be known before it is collected, as it will be the primary driver of the collection method and analysis performed. Table 37 and the following paragraphs discuss typical AF sampling requirements and associated action levels.

Table 37. Typical AF Radiological Sampling Requirements and Action Levels

Reason for Sampling	Guidance/Requirements	Action Level	Notes
Permit Compliance	AF Radioactive Material Permit Sealed Source Device Certificate	0.005 µCi removable contamination typically	Required for: Alpha sources >10 µCi Beta sources >100 µCi typically.
Generally Licensed Device	Manufacturers' labels or no less than 6 mo	0.005 µCi removable contamination typically	There are some exceptions for this requirement. See AFI 40-201 Attachment 3.
Waste Characterization	10 CFR 61 AF Radioactive Recycling and Disposal (AFRRAD) Requirements	Identification of all isotopes, quantification level is not well defined, contact AFRRAD for guidance	Analysis should be sufficient to ensure that limits specified in 10 CFR 61 are met or to meet the requirements of AFRRAD.
Internal Dose Assessment	AFI 48-148; 3.5.	Required for any individual who may receive greater than 10% of the annual limits of intake (ALI)	Investigation required for 25% of the ALI in a quarter. A baseline measurement must be conducted before any routine monitoring is started. Monitoring is typically quarterly but can be monthly.
Contamination Control	AFI 48-148 Table A4.2 (from Reg Guide 1.86) Local procedures may supersede	Other values for humans and emergencies can be found in National Council on Radiation Protection Report 161 or may be locally mandated	Removable contamination is typically measured with a wipe sample. Fixed contamination is typically measured with a handheld instrument. Even if below limits, contamination can be indicative of problems.
Permit Termination Final Status Survey	AFI 40-201 10 CFR 20.1402 Multi-Agency Radiation Survey & Site Investigation Manual (MARSSIM) (NUREG 1575)	25 mrem/yr	Limits will be specified in your decommissioning plan. Limits will be based upon limiting the dose to members of the public to less than 25 mrem annually from any remaining material.
Environmental Assessment	MARSSIM	15-25 mrem/yr or other limit beyond the scope of this document	
Transportation	49 CFR 173.443(a) Table 11	As low as reasonably achievable and 220 dpm/cm^2 beta 22 dpm/cm^2 alpha	Note: Typically this limit can be demonstrated by performing a wipe and measuring with a handheld instrument (except H-3, Ni-63, C-14). However, permitted materials, if the permit is being terminated, require a final leak test. 40-201 3.11.6.4.

4.3.1 Sealed Sources for Permit Compliance. AF Radioactive Material Permits will often specify that the sealed sources be surveyed on a routine basis. The following are requirements for a typical USAF permit. ***You should always review your permit for individual requirements.***

- *Frequency of Sampling:* typically every 6 months. "Sealed sources shall be tested for leakage and/or contamination at intervals not to exceed the intervals specified in the certificate of registration issued by the U.S. Nuclear Regulatory Commission under 10 CFR 32.210 or under equivalent regulations of an Agreement State. If sealed sources are not governed by a certificate of registration, they should be leak tested at 6 month intervals."

- *Sealed Source Device Registry (SSDR) Number.* For a device to be considered a sealed source by the Nuclear Regulatory Commission, it is typically assigned an SSDR number. This certifies that it has passed a battery of tests to ensure that it will not leak. As part of this registry, the device will be assigned a sampling interval. The value can typically be found in your permit application, which usually requires copies of the SSDR for devices. If not available and not specified in your permit, you should contact the manufacturer or the Radioisotope Committee to obtain a copy of the SSDR.

- *Leak Testing Methods.* Leak testing methods can be specified by the manufacturer, by technical order, or by a locally generated procedure. They typically involve wipe sampling specific areas of the device to determine if the material has leaked. In some cases, a swab may be used instead of a wipe for small enclosures. BEs should have written procedures for leak testing. If the procedure was submitted as part of your application, then the procedure is part of your permit and is mandated. Additional sampling requirements may be specified in your permit.

- *Transfers.* If you receive a new source and do not have a certificate from a transferor indicating that a leak test has been made within a specified interval, the source shall be leak tested within 30 days of receipt. The source shall not be used or transferred unless leak test results are less than ***0.005 µCi***. If the leak test results are 0.005 µCi or greater, contact the Radioisotope Committee Secretariat for assistance. A source that has contamination below this limit may still be a concern.

- *Sealed Sources not Requiring Testing.* Sealed sources need not be tested if they contain only hydrogen-3, they contain only a radioactive gas, the half-life of the isotope is 30 days or less, or they contain no more than 10 µCi of beta- and/or gamma-emitting material or not more than 10 µCi of alpha-emitting material.

- *Sealed Sources in Storage.* Sealed sources need not be tested if they are in storage and are not being used. However, when they are removed from storage for use or transferred to another person, and have not been tested within the required test interval, they shall be tested before use or transfer. No sealed source shall be stored for a period of more than 2 years without being tested for leakage and/or contamination.

4.3.2 Generally Licensed Devices (GLDs). AFI 40-201, *Managing Radioactive Materials in the US Air Force*, specifies the sampling requirements for GLDs. All GLDs must be tested for leakage on a routine basis. Exceptions to this include:

- Devices containing only krypton
- Devices containing only tritium
- Devices containing not more than 100 µCi of beta and/or gamma emitters or 10 µCi of alpha emitters and devices held in their initial shipping container prior to installation

Frequency of Sampling. The frequency of testing will be specified on the device label but cannot exceed 6 months. As with permits, the removable contamination from GLDs cannot exceed 0.005 µCi.

4.3.3 Waste Characterization. The isotopes and quantities of any radioactive material must be identified before disposal. Refer to 10 CFR 61, your base Radiation Safety Officer, and the AFRRAD office for guidance. The contact information for the AFFRAD office is below:

AFFRAD
ABW/CEV
1450 Littrell Road
Wright-Patterson AFB, OH 45433
Comm: 937-257-2010
DSN: 787-2010
Email: AFRRAD@wpafb.af.mil
https://afkm.wpafb.af.mil/community/views/home.aspx?Filter=OO-MS-MC-05

4.3.4 Internal Dose Assessment. For personnel who may be exposed to unsealed radioactive sources that may result in an uptake of more than 10% of the allowable limit, internal dose monitoring is required. Internal dose monitoring typically consists of submission of urine samples and/or fecal samples for analysis.

- *Annual Limits on Intake.* ALI are specified in 10 CFR 20 Appendix B. Operations involving unsealed quantities of radioactive materials should be evaluated to determine if 10% of the ALI may be exceeded. This can be done theoretically or by using bioassay monitoring.

- *Bioassay Monitoring*. Bioassay monitoring may be required to assess exposures during radiological incidents as well. Bioassay monitoring is beyond the scope of this guide. If you believe you have an operation that may require monitoring or evaluation, contact Customer Service for guidance.

4.3.5 Contamination Control. It is sometimes necessary to determine if an unsealed source has contaminated a surface or piece of equipment. Any time work with unsealed sources is conducted, an assessment should be made of the possibility of transfer of contamination and procedures should be implemented to identify any such contamination. Such contamination is usually identified using handheld instruments and swipes.

4.3.6 Permit Termination. AFI 40-201 requires that a final survey be conducted when a permit is terminated. The purpose of the survey is to ensure that no radioactive materials remain.

4.3.7 Environmental Assessment. To protect members of the public, environmental surveys may be conducted on AF installations to assess radioactive contamination. Such surveys should include detailed sampling and analysis plans that specify the details of any laboratory samples to be taken. Refer to the Data Quality Objectives discussion in Section 3 of this guide for additional guidance.

4.3.8 Transportation. Samples are not typically sent to the lab prior to shipping radioactive materials. However, this does not apply to low energy beta emitters such as H-3, C-14, and Ni-63. Swipes can usually be measured on site to meet transportation requirements. However, permits may require samples before a source is transferred or immediately after it is received. These must be processed by the lab.

4.4 Determining the Type of Analysis

The type of analysis required for a sample will typically be determined by the reason that the sample is collected. It is important to ensure that the type of analysis requested will meet the regulatory requirements or allow for an accurate assessment of some health risk. Samples can be analyzed using a variety of methods. It is important that you request the proper sampling method to ensure that you obtain the results you desire. Selection of the incorrect method may result in unneeded or incorrect data. The current analysis methods offered by the lab are listed in Table 38 and discussed in the accompanying paragraphs. Direct any questions to the lab CS for assistance.

Table 38. Radioanalysis Methods Available from USAFSAM/OEA

Type of Analysis	Analysis Results	Applicable Isotopes	Types of Media	Comments
Gamma Spectroscopy	Results will quantify most gamma-emitting isotopes present with energy >50 keV. Minimum detectable activity (MDA) 10-1000 pCi/sample.	Cs-137, Co-60, Co-57, Cd-109, Am-241, U-238, U-235, Ra-226, etc.	Swipe, liquid, filter, soil, solids, are standard; contact CS for nonstandard media	Naturally occurring isotopes are typically not reported but can be requested if needed.
Alpha Spectroscopy	Analysis quantifies for a particular isotope. Most common alpha-emitting isotopes. MDA >0.1 pCi/sample.	Am-241, U-238, U-235, U-234, Pu-238, Pu-239, Th-232	All; contact CS for nonstandard sample types	The sample is chemically processed and, unlike gamma spec, a specific isotope must be requested.
Gross Alpha Counting	Will quantify the number of alpha decays in a sample. Will not identify the isotope present. MDA <10 pCi/sample.	Any alpha emitters	Soil, water, wipe, vegetation, others possible upon request	Used as a screening tool to identify the presence of alpha emitters. Elevated results for unknown nuclides may indicate the need for gamma or alpha spec.
Gross Beta Counting	Will quantify the number of beta decays in a sample. Quantification results should be used with caution for unknown isotopes, as response is energy dependent.	Any beta emitter mod to high energy (>300 KeV); low energy beta, see LSC below	Soil, water, wipe, vegetation, urine, others possible upon request	Used as a screening tool to identify the presence of beta emitters. Elevated beta results for unknown sources may indicate the need for further analysis.
Liquid Scintillation Counting	Will quantify low energy beta emitters, specifically H-3, Ni-63, and C-14. Will quantify the specific isotope requested.	H-3, Ni-63, C-14	Any liquid sample or wipe	Used to quantify specific low energy beta emitters.
Inductively-Coupled Mass Spectroscopy ICP-MS	Currently used to measure U-238 and U-235 to a high degree of precision	Quantifies U-238 to fCi and can be used to accurately measure enrichment levels	Most, water soil, urine	A highly accurate and inexpensive system for quantifying U-238 and U-235.

Note: MDAs are typical and will vary from sample to sample. If the MDA you require is near or below those listed, contact Customer Service for further assistance.

4.4.1 Gross Alpha/Beta Counting. In gross alpha and beta counting, the sample is prepared for analysis and then placed on a metal disc. The disc is then placed in a volume of gas and counted. The instrument can differentiate between alphas and betas but not between different isotopes. No isotope identification is possible. This method is typically used as a screening tool but can be used to quantify some isotopes in samples that may only contain a single isotope.

4.4.2 Liquid Scintillation Counting. In LSC, the sample is placed in a solution that emits light when exposed to radiation. This method can be used to measure low energy beta emitters. Typically the method is used to measure H-3, Ni-63, and C-14.

4.4.3 Alpha Spectroscopy/Spectrometry. In alpha spectroscopy, samples are prepared by chemical separation. The sample is chemically digested to make it into a solution. The element of interest is separated from all others present as much as possible. This purified fraction of interest is then placed on a small metal disc and measured in an alpha spectrometer. An alpha spectrometer then counts the number of alpha particles and their energies emitted. Using these data, the activity of alpha-emitting isotopes of that element can be quantified. Preparation and analysis time is quite intensive and requires long turnaround times.

4.4.4 Gamma Ray Spectroscopy/Spectrometry. Gamma ray spectroscopy uses high purity germanium detectors to measure the number and energy of gamma rays emanating from a sample. Energies from 50 keV and above can be measured using gamma spectroscopy. Using the energies of the emitted gammas, an unknown isotope can be identified (spectroscopy). By using the yield and number of gammas emitted, the activity of each radioactive isotope in the sample can be identified (spectrometry). Gamma ray spectroscopy should be requested when you have a sample with an unknown isotope present, as well as gross alpha/beta. It should also be used for determining the activity concentration of each gamma-emitting isotope in a sample. Only minimal sample preparation is required for a sample to be analyzed using gamma spectroscopy; however, count times are very long (approx. 8 hours each sample). The sample is dried thoroughly to remove any moisture present and then placed into a uniformly shaped sample container for analysis. As with alpha spec, sample turnaround is slow due to long count times.

- *Precautions*. When determining activity present in a sample, the assumption is made that the activity is uniformly distributed throughout the sample. In the event this is not the case, the actual activity present in the sample may be over- or underreported. If you suspect that a sample may contain nonuniform activity, then you should contact Customer Service for further guidance.

- *Disadvantages*. Gamma spectroscopy is a powerful analysis method, but it does have some disadvantages. It requires long measurement times, and the detectors and equipment are quite expensive to purchase and maintain. Interpretation of the spectrum for reporting requires a significant amount of time and expertise.

4.4.5 ICP-MS. ICP-MS performs multi-elemental analysis with excellent sensitivity and high sample throughput. The ICP-MS instrument employs a plasma (ICP) as the ionization source and a mass spectrometer analyzer to detect ions produced. It can simultaneously measure most elements in the periodic table and determine analyte concentration down to the parts per trillion or femto-curie level. It can perform qualitative and quantitative analysis, and since it employs a mass analyzer, it can also measure isotopic ratios.

4.4.6 Recommended Analysis Based on Sample Type. Table 39 outlines recommended analysis based on sample type and isotope of concern.

Table 39. Recommended Radioanalyses for Different Types of Samples

Sample Type & Isotope	Recommended Analysis	Comments
Wipe for Permit Leak Test Compliance not Including H-3, Ni-63, C-14	Specify the permitted isotope and request gross alpha/beta analysis	This is not appropriate for a few pure gamma-emitting isotopes. The only one commonly used in the AF is Tc-99m.
Wipe for Permit Leak Test Compliance for H-3, Ni-63, C-14	Specify the permitted isotope and request LSC.	Use wet method for smears, particularly H3. Contact Lab CS for info and sampling media, if needed.
Waste Characterization	Will vary depending on the nuclides in the waste; for unknown wastes request gamma spectroscopy, LSC for H-3 and Ni-63, gross alpha/beta counting.	Elevated levels of alpha counting should be followed up with alpha spectroscopy to determine the alpha emitter present if it cannot be determined from other analysis.
Bioassay – Baseline	Request analysis for nuclides of concern based on exposure/potential exposure; additionally gross alpha/beta analysis to detect the presence of unknown nuclides.	When initiating a new program of analysis, it is recommended to contact CS for guidance, as bioassay is an extremely complex topic.
Bioassay- Routine	Request analysis for nuclides of concern based on exposure/potential exposure; additionally gross alpha/beta analysis to detect the presence of unknown nuclides.	When initiating a new program of analysis, it is recommended to contact CS for guidance, as bioassay is an extremely complex topic.
Contamination Control	Except in special cases gross alpha/ beta counting is sufficient except for low energy beta emitters, which should be analyzed by LSC (H-3, C-14, Ni-63).	
Permit Termination **Final Status Survey**	Except in special cases gross alpha/ beta counting is sufficient except for low energy beta emitters, which should be analyzed by LSC (H-3, C-14, Ni-63).	
Environmental Assessment	See the sampling plan or contact USAFSAM/OEA for the site. Typically a variety of sample analysis is required.	Base analysis on current operations or historical operations of site. Contact ESOH service for additional guidance. Contact Lab CS for analytical guidance.
Transportation	In most cases swipes can be measured on site. No lab analysis is required.	

4.5 Radionuclides of Interest

The following section discusses several radionuclides of interest to AF operations.

4.5.1 Tritium. Tritium (H-3) is an isotope of hydrogen and can be found in self-luminous lights, emergency exit signs, lensatic compasses, as a trace element in many types of biomedical research, and as a component of some nuclear weapons. Tritium is analyzed using LSC.

4.5.2 Nickel-63. Ni-63 is a radionuclide that is typically found in coolant water of nuclear power reactors. It is formed by neutron capture from nickel present in steel piping. Ni-63 is also used as an ionizing source in ion mobility mass spectrometers used to detect chemical warfare agents. Ni-63 is a low energy beta emitter, typically analyzed by LSC.

4.5.3 Carbon-14. C-14 is commonly used in research laboratories, although it has a few nonlaboratory applications in the AF as well. It is also produced naturally in the atmosphere. Like tritium, C-14 is readily absorbed by living systems and becomes evenly distributed in the body. The most common pathway to exposure is direct inhalation in the workplace, in the environment, and by ingestion of foodstuffs that have incorporated C-14 by photosynthesis. Like tritium, C-14 is a very low energy beta emitter and is analyzed using LSC.

4.5.4 Strontium-90 and Strontium-89. Strontium is an important component of fallout from nuclear weapons. Sr-90 may be found in the workplace, where it is used in certain types of gauges, for industrial and medical radiation purposes, and in certain types of research. Of the various isotopes of strontium, Sr-90 is the most important because of its long half-life (28 years). It has a short-lived daughter, Y-90, that emits high energy beta particles. Sr-90 is a relatively high energy beta emitter. Sr-90 is typically analyzed by using gross beta counting. For more precise measurements, please contact the lab for further information.

4.5.5 Cesium-137 and Cesium-134. Cs-137 is a fission product and is found in the environment due to fallout from nuclear weapons. It may be found in the workplace in the form of sealed sources used for irradiation and industrial radiography purposes. The primary hazard from Cs-137 is external exposure. Cs-137 is a beta emitter with a high energy gamma and has a relatively long half-life. Cs-134 is a beta and gamma emitter as well with a much shorter half-life of 2 years and is typically found in much lower concentrations than Cs-137. Cs-137 and Cs-134 are typically analyzed using gamma spectroscopy.

4.5.6 Isotopes of Iodine. I-131 and I-123 are found in the nuclear medicine departments of most large hospitals and as an effluent from nuclear facilities. The thyroid is the critical organ where iodine concentrates. Of the various radioisotopes of iodine, I-131 is the most important, followed by I-129 and I-133. I-131 has several important pathways to personnel. In the workplace, direct inhalation or ingestion is of primary concern. I-129 is primarily a beta emitter. I-129 and I-133 are both beta and gamma emitters. Iodine compounds are typically quite volatile, and care must be taken to account for this when sampling.

4.5.7 Cobalt-60, Manganese-54, Cobalt-58, Cobalt-57, Zinc-65, Iron-55, and Iron-59. Co-60, Mn-54, Co-58, Zn-65, Fe-55, and Fe-59 are activation products normally associated with the operation of nuclear reactors or they can be produced in an accelerator. Each nuclide may be found in the workplace as a check or calibration source and, in the case of Co-60, in large

irradiation and industrial radiography sources and medical teletherapy sources. All these sources are normally sealed, with the only potential for exposure being external radiation or a source leak. These are all photon (gamma/x-ray) emitters and are typically analyzed using gamma spectroscopy.

4.5.8 Radium-226 and Radium-228. A common isotope encountered in military projects is uranium. This isotope was used extensively since the turn of the century to produce self-luminous dials and is often found on many of the dial faces of older aircraft. It has also been used in the form of small sealed sources for radiation cancer therapy and radiography. Radium is a naturally occurring radionuclide, and as a result may be found in high concentrations in some soils, in drinking water, and in some foods. Worker exposures include external radiation, ingestion of loose contamination and, under unusual circumstances, inhalation of aerosols. Radium is an alpha and beta emitter. Swipes can be measured for radium via gross alpha/beta. Radium can be measured in soil and swipes with gamma spectroscopy, typically by measuring the progeny of radium. The sample is sealed and allowed to decay for 30 days, and then the progeny are measured. Thus, analyzing for radium can be a time-consuming process.

4.5.9 Radon. Radon is a naturally occurring noble gas. Radon is a decay product of radium, which is a decay product of uranium. Radon is constantly produced in soil and building materials where uranium/radium exists. Because the gas is inert and has a 3.8-day half-life, radon can diffuse through the soil, where it enters the atmosphere or groundwater. Radon in the atmosphere decays back into particulate daughters that adhere to dust particles. These aerosols may then be inhaled or deposited on foodstuffs and ingested. The average annual dose to members of the general public from man-made and natural radiation sources is 620 mrem. Of this, 230 mrem is attributed to inhaled radon progeny. The AF Radon Assessment and Mitigation Program was designed to assess significant exposures to radon in the workplace and residences of AF personnel and mitigate those measured to be greater than 4 pCi/L. Primary concern from radon is the alpha emission from its daughter products; however, radon is also a gamma emitter. Sampling for radon is accomplished using direct reading instruments and electrets. Contact the lab for further guidance.

4.5.10 Thorium-232. Th-232 is a naturally occurring isotope of thorium. Thorium is common material used in many commercial and military applications. It has been used as an optical lens coating, in gas mantles, in thoriated tungsten welding rods, in fluorescent lamp starters, and as a component of magnesium-thorium alloys (magthor). These alloys have been used extensively in the skins of many aircraft and missiles, as well as in engine components. Thoriated alloys are often used in areas requiring high heat resistance and high tensile strength. Th-232 is naturally occurring; thus, any thorium metal will be radioactive. Thorium is also naturally present in soil and water. Thorium is an alpha and gamma emitter. Thorium can be measured either via gross alpha/beta, gamma spectroscopy, or alpha spectroscopy.

4.5.11 Uranium. Uranium is a radioactive element that occurs naturally in the earth's crust. The majority of natural uranium is made up of U-238. It has a half-life of 4.5×10^9 years. Naturally occurring isotopes include U-238, U-235, and U-234. Mined uranium is processed to create uranium enriched in the isotope U-235, which then is used as fuel in modern nuclear power plants and naval nuclear vessels. The by-product of uranium enrichment is U-238, which has a lower concentration of U-235 than in naturally occurring uranium. This by-product is also called depleted uranium. Depleted uranium has been used extensively in the military as counterweights, armor, and armor-piercing munitions. It also was used commercially as a glaze and colorant for

ceramics, jewelry, and glasses, and as a mildly radioactive shielding material. Exposure to uranium in the workplace can include external exposure from handling munitions and counterweights and, under more unusual conditions, ingestion or inhalation of uranium contamination. Examples of sites where loose contamination may be present include target ranges or battle areas where depleted uranium penetrators have been used. Nonenriched and depleted uranium is a chemical hazard and not a radiological hazard. Enriched uranium can be a radiological hazard. U-238, U-235, and U-234 are measured using both gamma spectroscopy and alpha spectroscopy.

4.5.12 Plutonium-239 and Plutonium-238. Plutonium is not a naturally occurring element. Pu-239 is used in nuclear weapons. Pu-238 is used primarily as a heat source in radioisotopic thermoelectric generators to provide power in extremely remote environments. Pu-238 powered radioisotopic thermoelectric generators have been used successfully to power such deep space satellites as Cassini, Galileo and, most recently, the Mars science lab. Pu-239, Pu-238, and Pu-240 are typically analyzed using alpha spectroscopy.

4.6 Wipe Samples

Analytical results will be inaccurate unless careful attention has been given to sampling procedures. The following instructions provide detailed, step-by-step procedures for collecting wipe samples for radioanalyses.

4.6.1 Wipe Collection Procedures (Non-Tritium). Swipes, also known as smears or wipes, provide a semi-quantitative measure of removable activity. They are collected by wiping an area using a filter paper while applying moderate pressure. The area of concern for smear surveys will usually be 100 cm^2. Current surface contamination guidelines are specified in terms of this area size. If a different area is swiped, as for objects with a smaller area, the area should be noted on AF Form 2753. If the surface is thickly coated with particulate material, such as rust or dirt, a sample of the particulate material should be collected as a separate sample instead of attempting to use a smear.

Slightly moistened filter paper with diameters from around 30 mm to 50 mm is used for smears. For surveys of small penetrations such as cracks or anchor-bolt holes, moistened cotton swabs may be used to wipe the area of concern. All smears, with the exception of those for tritium, are placed in an individual plastic sealable bag to prevent cross-contamination while awaiting analysis. Tritium swipes are immersed in liquid scintillation counting vials, provided by the laboratory, immediately after swipe collection.

It is unlikely that outside surfaces, exposed to wind and rain, will have significant levels of removable surface activity. Swipes for removable surface activity are not appropriate for use on soil.

Materials:

- Filter paper discs (Whatman® No. 41 or equivalent), 4.25 cm or less in diameter. Cotton tip applicator sticks may be used for wipe sample sources taken in accordance with AF Technical Order 11H4-8-5-1. The filter papers are standard non-medical items and may be obtained by using a Whatman Catalog, catalog no. 1001-042. The Whatman Company can be reached at 1-800-Whatman. ***Do not use swipe papers with "sticky" backs.***
- Deionized water

- AF Form 2753 (1 per sample), pencil and pen
- Small plastic sealable bag (1 per sample)
- Gloves
- Tape measure or 100-cm^2 template

Procedures:

- Protective Equipment: Wear protective gloves when sampling. If it is suspected that samples may be grossly contaminated, change gloves between each wipe to prevent cross contamination. When sampling, avoid touching the sample surface as much as possible.
- Field Blanks: For each batch of samples submitted (a batch is typically 1-20 samples), collect a field blank. A field blank is collected exactly like other samples but at a location nearby that is known to be free of radioactive contamination.
- Place a small "x" IN PENCIL ONLY on the outer edge of the filter paper on the side that is to touch the radioactive source or area being tested for contamination.
- Apply a few drops of DI water so the wipe is damp but not soaked. If a cotton tip applicator is used, apply a drop of DI water to the top of the applicator.
- In a slow back and forth "s" motion applying moderate pressure, swipe an area of 100 cm^2. Repeat the process at a 90-degree angle direction using the same wipe. If a cotton tip is used, wipe as much of the area that may be contaminated as possible using moderate pressure up to 100 cm^2. Use caution not to bore a hole through the paper.
- Allow sample to dry before placing in sample container.
- Place **unfolded** disc (or cotton tip stick) in the plastic bag (applicator sticks may be broken if necessary to fit the bag).
- Complete AF Form 2753 per instructions in Appendix H. Write the sample number on the plastic bag and attach the form (by stapling) to the bag. Make sure to document the area sampled in the comments section of AF Form 2753.

4.6.2 Wipe Collection Procedures for Tritium. Because tritium is volatile, it is important that it be contained immediately after sampling to get an accurate result. For this reason, the wipe must be placed immediately in a special vial. These vials are provided by the lab. Call Customer Service for the necessary sampling materials, swipes, and liquid scintillation counting vials.

Materials:

- Filter paper discs (Whatman® No. 41 or equivalent), 4.25 cm or less in diameter. Cotton tip applicator sticks may be used for wipe samples of Cs-137 sources taken in accordance with AF Technical Order 11H4-8-5-1. The filter papers are standard nonmedical items and may be obtained by using a Whatman Catalog, catalog no. 1001-042. The Whatman Company can be reached at 1-800-Whatman. ***Do not use wipe papers with "sticky" backs.***
- Scintillation vials, 1 per sample
- DI water
- AF Form 2753 (1 per sample), pencil and pen
- Gloves

- Tape measure or 100-cm^2 template

Procedures:

- Protective Equipment: Wear protective gloves when sampling. If it is suspected that samples may be grossly contaminated, change gloves between each wipe to prevent cross contamination. When sampling, avoid touching the sample surface as much as possible.
- Field Blanks: For each batch of samples submitted (a batch is typically 1-20 samples), collect a field blank. A field blank is collected exactly like other samples but at a location nearby that is known to be free of radioactive contamination.
- Moisten the wipe lightly (use a spray water bottle) and wipe an area of 100 cm^2 by gently rubbing (moderate pressure) two times. It is not necessary to place an "x" on the wipe.
- Place the wipe immediately into the provided, pre-filled, liquid scintillation counting vial. Fill out an AF Form 2753 (see Appendix H), marking the top of the scintillation vial with the same base sample number used on the form. Make sure to document the area swiped in the comments section of AF Form 2753. NOTE: DO NOT MARK THE SIDE OF THE VIAL.
- Place the lid on the vial.
- Return both used and unused vials and AF Form 2753s to the laboratory in the shipping container provided.

4.7 Biological Samples (Bioassay)

Bioassay samples are used to assess the extent of internal exposures to radioactive materials. By measuring the amount of radioactive material leaving the body, an estimate can be made of the radioactive material taken into the body and a dose estimate can be made. Bioassay sampling and interpretation is a complex science. If you are considering performing bioassay sampling, you should contact Customer Service for guidance.

Bioassay monitoring can either be conducted on a routine basis or a nonroutine basis. All individuals who are routinely monitored should have a baseline sample collected. The baseline sample is used to assess if the individual may have had any previous exposures and to identify typical levels of naturally occurring isotopes present. Routine results are then compared to baseline results to help identify any change. Personnel who may be unexpectedly exposed to >10% of the occupational limit in a single exposure should consider a baseline sample as well.

4.7.1 Nasal Swabs. Nasal swabs are used as a nonquantitative screening tool to assess whether an inhalation (and to a lesser extent an ingestion) of radiological material has occurred. Nasal swabs are not indicated under normal occupational monitoring conditions. It is important to note that nasal swabs are only an indicator of an inhalation exposure and cannot be used to quantitatively assess the amount of contamination inhaled. It should only be used as a positive and negative indicator of inhalation.

For a nasal swab to provide meaningful data, the sample **must** be collected within ***1 hour*** of the termination of exposure. There is no need for a *pre-exposure* or *baseline* nasal swab.

Materials:

- A cotton-tipped applicator, FSN 6640-00-729-6484, moistened with water, is recommended. If these are not available, any moistened cotton swab may be substituted.

- DI water
- Gloves

Procedures:

- Protective Equipment: Wear protective gloves when sampling. If it is suspected that samples may be grossly contaminated, change gloves between each swab to prevent cross contamination. When sampling, avoid touching the sample surface as much as possible. Additional protective equipment may be required if the sample is taken at a contamination control station; however, samples should only be taken in areas free of airborne contamination.
- Use a separate applicator for each nostril. Gently rub the tip around the inside of the nasal passages. It is not necessary to swab more than just the first quarter to half inch of the nasal passage.
- After taking the sample, place each applicator in a culture tube or bag, and then place the tube or bag in an envelope. Do not use tubes with culture media. Label sample with identifying information: name, rank, social security number (SSN), home base, and organization. Note that each swab (one per nostril) is a separate sample, with its own sample number and completed AF Form 2753. Include details about the sample event in the comments section, if needed.
- When completing the sample form, be sure to indicate the isotope of concern and the requested analysis.

4.7.2 Urine Samples. Urine analyses are the most common type of in-vitro bioassay technique. Urine samples are used to assess inhalation or ingestion intakes of soluble forms of many radionuclides. The sensitivity of the technique in measuring an intake is dependent on when the sample was collected post intake, as well as the specific solubility (chemical form) of the radionuclide and the exposure pathway, e.g., ingestion versus inhalation. The timing of urine samples can be critical for maximum sensitivity. It is important that you contact Customer Service for guidance immediately if you suspect an exposure. In general, urine samples should be collected within the first week after a suspected exposure for maximum sensitivity. Further sampling may be required under the guidance of the laboratory.

Materials:

- 24-hour urine container, 3.0 liters, (Cs (40) Curtin Matheson Scientific Catalog #282-252), or a new collapsible, square, 1-gallon cubetainer (FSN 6640-00-117-7855) and a new disposable funnel. If neither container is available, contact Customer Service.

Procedures:

- Instruct the person on the following procedures: Discard the first morning void and collect all other voids during the next 24 hours, including the first void the following morning. Collect the specimen in a noncontaminated area. Use caution to avoid surface contamination of the collection container. Wash hands prior to capturing each void. Collect all urine over a 24-hour period. Keep the container sealed between each void. Multiple containers may be used if needed.

- A normal 24-hour total urine volume is 1000-2000 mL. Do not add any chemical or reagent as a preservative. Keep the sample cooled during collection and transport to control odor and bacterial growth and to minimize development of solids in the sample.
- Properly identify each sample container with name, SSN, and collection start and stop dates. Submit a completed AF Form 2753 with the sample. Ship to the lab as soon as possible.
- Indicate if sample is baseline, routine, or emergency and list isotopes of concern and analysis requested. Contact lab CS for further assistance.

4.7.3 Fecal Samples. Fecal analyses are considered the most sensitive means of in-vitro bioassay to detect inhalation or ingestion intakes of insoluble radionuclides, particularly transuranics such as americium, plutonium, thorium, and uranium. As with urine samples, the sensitivity of the technique is highly dependent on the specific chemical form of the nuclide, as well as the route of exposure. Even more important is the time between a suspected exposure and sample collection. Since insoluble compounds pass through the gastrointestinal tract rapidly post exposure, you should contact the lab immediately if a suspected exposure occurs. Typically, fecal samples should be collected within 5 days following a suspected acute intake.

Materials:

- 1-gallon plastic bags
- Cardboard box

Procedures:

- Label 5-10 plastic bags with the individual's name and SSN.
- All fecal matter should be collected over a 24-hour period. Instruct the individual to collect the specimen in a noncontaminated area, using care to avoid surface contamination of the collection bags. This will include washing hands prior to capturing the specimen.
- Defecate directly into a 1-gallon new plastic bag. Either zip-locking or twist tie closure is acceptable.
- Seal the bag, and store in a cardboard box or other sturdy container.
- Repeat for all episodes in a 24-hour period, placing each sampling in the same cardboard carton. The sample may be kept cool or frozen during collection to control odor and bacterial growth.
- Once complete, place all sample bags in a larger plastic bag and seal.
- Properly identify the sample with name, SSN, and collection start and stop date and time. Submit a completed AF Form 2753 with the sample.
- Samples should be frozen before shipment, time permitting, to control odors.

4.7.4 Breathing Zone Air Samples. The most direct measure of exposure to particulate radioactivity is a breathing zone air sample. The method uses a personal air sampling pump calibrated to a known flow rate (commonly 2 LPM) and fitted with a submicron membrane (e.g., 0.7 m Millipore) air filter cartridge mounted near the individual's breathing zone.

Materials:

- Personal air sampling pump
- Air filter cartridge

Procedures:

- Follow the manufacturer's instructions for maintenance, calibration, and operation of the personal air sampling pump.
- When the individual is prepared to enter a contaminated area, place a new filter cartridge on the pump. Suspend the filter, open faced, near the individual's breathing zone (retain the cover of the filter cartridge for reuse after sampling).
- Turn on the pump; record the initial flow rate and time activated.
- When the individual exits the area, record the sampler flow rate and turn off the sampler. Record the total sampling time, average flow rate over the sampling period, and, if provided, the integrated sample volumes.
- Remove the filter cartridge from the sampler with caution to avoid external contamination of the cartridge and filter. Replace the top cover of the cartridge to protect the filter media.
- Prepare a field blank sample. The blank sample should accompany the actual sample during all phases of the sampling except actual collection.
- Place the cartridge in a small envelope or box. The outer envelope should be marked with name, SSN, collection start and stop times and dates, average flow rate, and calculated or measured integrated sample volume. Include a brief history or reason for sampling, the submitting base, the base sample number, and all other identifying information. Submit a completed AF Form 2753 with the sample.

4.8 Soil Samples

Soil sampling procedures depend on the purpose of the sampling program. In all cases, careful selection of control (background) samples associated with the sampling site is required to allow interpretation of results.

Equipment. The selection of proper sampling equipment is important to ensure that samples are collected effectively and efficiently. Sampling equipment generally consists of a tool to collect the sample and a container to hold the collected sample.

Sampling tools are selected based on the type of soil, sample depth, number of samples required, and training of available personnel. The selection of a sampling tool may also be based on the expected use of the results. For example, if a soil sample is collected to verify the depth profile used to develop the calibration for *in-situ* gamma spectrometry, it is important to preserve the soil core. Table 40 lists several examples of tools used for collecting soil samples, situations where they are applicable, and some advantages and disadvantages involved in their use.

Table 40. Radiological Soil Sampling Tools and Typical Uses

Equipment	Application	Advantages/Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stone or dry soil.
Scoop or trowel	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Bulb planter	Soft soil, 0-15 cm (0-6 in.)	Easy to use and decontaminate: uniform diameter and sample volume; preserves soil core; limited depth capability; can be difficult to decontaminate.
Soil coring device	Soft soil, 0-60 cm (0-24 in.)	Relatively easy to use; preserves soil core; limited depth capability; can be difficult to decontaminate.
Thin-wall tube sampler	Soft soil, 0-3 m (0-10 ft)	Easy to use; preserves soil core; easy to decontaminate; can be difficult to remove cores.
Split spoon sampler	Soil, to bedrock	Excellent depth range; preserves soil core; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.
Shelby tube sampler	Soft soil, to bedrock	Excellent depth range; preserves soil core; tube may be used for shipping core to lab; may be used in conjunction with drill rig for obtaining deep cores.
Bucket auger	Soft soil, 7.5 cm - 3 m (3 in. - 10 ft)	Easy to use; good depth range; uniform diameter and sample volume; may disrupt and mix soil horizons greater than 15 cm.
Hand -operated power auger	Soil, 15 cm - 4.5 m (6 in. -15 ft)	Good depth range; generally used in conjunction with bucket auger; destroys soil core; requires two or more operators; can be difficult to decontaminate.

Containers. Sampling containers are generally not a major concern for collecting surface soil samples. Large zip lock bags are recommended. Samples should be double bagged with both inner and outer bags labeled with the sample number. These containers are fairly economical; provide easy access for adding and removing samples; and resist chemicals, breaking, and temperature extremes. Glass containers are also acceptable, but they are fragile and tend to break during shipment. The following are common sample containers:

- Soil Jars, 1 Gallon, Screw Cap, Cs, 8125-01-227-6038
- Bag, Plastic, Interlocking Seal, 12x12, 8105-00-837-7757
- Bag, Plastic, Interlocking Seal, 8x8, 8105-00-837-7755

Sample Size. Sample size should be consistent with the requirements of the analytical method. The following minimum quantities are necessary for analysis:

- Gamma spectrometry plus gross alpha and/or gross beta: 2 kg of soil (approximately 1ft^2 area 3 inches deep).
- Gross alpha and/or gross beta: 100 g.

Purpose of Soil Sampling. It is important to understand the purpose of a soil sample in selecting the appropriate sampling method. The two most common reasons for collecting soil samples are to measure surface deposition or to measure total activity in soil.

Surface Deposition. Surface deposition is of primary interest in response scenarios. Surface deposition is often used to estimate airborne concentrations and external dose rates, estimate the total activity released, and validate predictive models (e.g., HPAC). Surface deposition is the total amount of radioactive material deposited over a fixed surface area. When collecting these types of samples, the depth should not be deeper than the first few centimeters of soil. All surface materials should be included in the sample. This includes vegetation, rocks, or other debris that could have material deposited on them. It is important, though, to pick a flat area that is as free of debris as possible. Additionally, it is important to pick an area that is representative. The sample should be collected in an area away from buildings or other obstructions that could significantly alter wind patterns.

Total Soil Activity. Measurement of total soil activity is usually of concern during environmental remediation and assessment operations. The activity per unit mass of soil is used to estimate the level of contamination at a location. The level of contamination can then be used to estimate potential doses. These types of samples are usually conducted after periods long enough past deposition that all of the radiological material has been incorporated into the soil matrix. The material is no longer concentrated primarily on the surface. For this reason it is important to not add extra mass to the sample that is likely not homogenous with the rest. When performing such sampling, it is typical to discard any surface debris not representative of the sample or to collect it and analyze it separately.

4.8.1 Surface Deposition Soil Sampling Using the Trench Method. To collect a representative soil sample, choose soil that is relatively dry, except for sediment, and is in a flat, open area. Do not sample under trees, bushes, or other overhanging objects. Avoid windows or areas next to roads. If the area to be sampled is covered with vegetation, leaves, etc., treat that portion as a separate vegetation sample.

Each group of soil samples should include a field blank sample that is collected exactly as the other samples. Field blanks should be collected in an area that is known to be free of contamination but otherwise has similar conditions, e.g., same type of soil, vegetation, etc.

Materials:

- Quart-size sealable bags
- Hammer, if soil is compacted
- Sampling frame, 10 x 10 cm
- Work gloves
- Flat trowel
- Tape measure
- Disposable gloves

Procedures:

- To avoid contamination, place plastic bags on the ground; lay the clipboard, instruments, and tools on the bags.
- On the sample form, record the GPS reading, location, time, date, and other descriptive information.
- Put on work gloves over disposable gloves.
- Survey the site using an appropriate survey meter, taking readings approximately 1 m (3 ft) (if appropriate) and at 2.5 cm (1 in.) above ground. Record the readings.
- Use an indelible ink pen to record the sample number on the sample container.
- Be careful not to disturb the sample collection area while digging the trench.
- Using a trowel, dig a trench 45 cm long x 15 cm wide x 15 cm deep (18 x 6 x 6 in.). Fashion a vertical surface that is as straight as possible (Figure 26).
- Place the open end of the sampling frame against the edge of the trench from a 10-cm x 10-cm (4- x 4-in.) square sample area. Press or tap (if hard) the cutter edge into the soil to stops (2 cm deep).
- Slide the flat trowel under the sampling frame, pick up the sample, and slowly dump it into a sealable bag. Check that the sample number is on the container.
- If a sampling frame is not available, measure a 10-cm x 10-cm area. Using any digging tool, collect the soil to a depth of 2 cm as evenly as possible. If additional volume is needed, collect adjacent 10-cm x 10-cm areas until sufficient volume is obtained.
- Any debris, vegetation, rocks, or other nonsoil material should be removed by hand from the sample. For surface deposition, the debris should be submitted as a separate sample for analysis.
- Record the depth taken and surface area on the sample form.
- Clean the sampling equipment with water.

4.8.2 Total Activity Soil Sampling Using the Trench Method. To collect a representative soil sample, choose soil that is relatively dry, except for sediment, and is in a flat, open area. Do not sample under trees, bushes, or other overhanging objects. Avoid windrows or areas next to roads. If the area to be sampled is covered with vegetation, leaves, etc., treat that portion as a separate vegetation sample.

Materials:

- Gallon-size sealable bags
- Hammer, if soil is compacted
- Sampling frame, 10 cm x 10 cm
- Work gloves
- Flat trowel
- Tape measure
- Disposable gloves

Procedures:

- To avoid contamination, place plastic bags on the ground; lay the clipboard, instruments, and tools on the bags.
- On the sample form, record the GPS reading, location, time, date, and other descriptive information.
- Put on work gloves over disposable gloves.
- Survey the site using an appropriate survey meter, taking readings approximately 1 m (3 ft) (if appropriate) and at 2.5 cm (1 in.) above the ground. Record the readings.
- Use an indelible ink pen to record the sample number on the sample container.
- Be careful not to disturb the sample collection area while digging the trench.
- Using a trowel, dig a trench 45 cm long x 15 cm wide x 15 cm deep (18 x 6 x 6 in.). Fashion a vertical surface that is as straight as possible (Figure 26 below).
- Using a small trowel or other digging implement, collect the soil to a depth of 6 in. Alternate depths may be used if needed. The depth of samples may be specified in survey plans.
- Slide the flat trowel under the sampling frame, pick up the sample, and slowly dump it into a sealable bag. Check that the sample number is on the container.
- Any debris, vegetation, rocks, or other nonsoil material should be removed by hand from the sample. For total activity, the debris may be discarded or submitted as a separate sample for analysis.
- Record the depth taken and surface area on the sample form.
- Clean the sampling equipment with water.

4.8.3 Surface Deposition Core Sampling. The procedure described here is designed to obtain samples that will measure the total amount of an initially airborne contaminant that has fallen out in a given area. The core method is typically faster in soft soils, although it is often not as accurate as the trench method.

Procedures:

- Following the selection of an undisturbed site that meets the criteria previously discussed, lay out a straight line transect about 4.5 m long. If the site is to be re-sampled at a later time, record distances to fixed landmarks to identify the relative location of the transect or use an accurate GPS device.
- If the vegetation cover is not to be included with the soil sample, or is to be kept as a separate sample, remove vegetation to the surface level.
- Using a 2- to 5-cm depth top soil cutter, press it into the ground without twisting or disturbing the grass cover or surface soil. This may best be accomplished by stepping on the rim of the cutter with both shoe heels. If more force is required, a rubber mallet may be used. Gently twist the handle of the cutter to cleanly remove the top soil plug. Place the core in a plastic sampling bag.

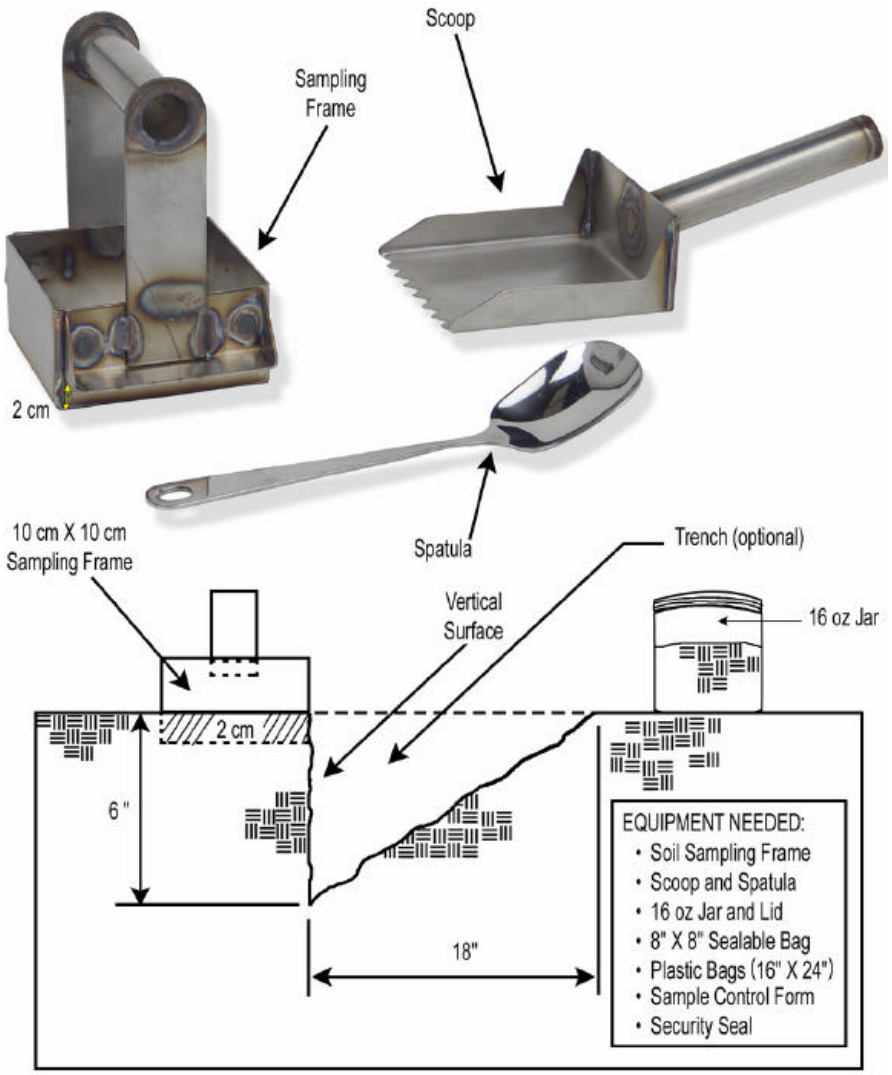


Figure 26. Soil Sampling Frame for Radiologicals

- Repeat the process until the desired number of cores has been sampled. Ten cores are recommended for providing a representative sample. Compositing soil samples can be used to provide a larger sample volume and possibly a more representative sample of the area. Take 10 top soil cores in a straight line about 30 cm apart, placing the cores in a sample bag. (The total area sampled is 620 cm^2.)
- Sometimes it may not be possible to remove a 5-cm depth plug cleanly because of a thick root mat. If the top soil and bottom soil are to be combined, a 10-cm or 15-cm depth cutter may be used to remove the top soil by pounding it part way into the ground with the rubber mallet, until it is possible to remove the core intact. This may not always be appropriate, however, if surface deposition is of concern.
- After collection, label the plastic bag containing the sample. The sample form should include the date, location, and depth.

4.8.4 Incremental Core Sampling. A depth profile is only useful for finding the relative vertical distribution of the radionuclide. Since only 100-300 cm^2 of surface area at one spot is sampled when taking depth increments, the integrated deposit is not necessarily representative of the area. The trench method is more time consuming and more difficult than taking core samples. Therefore, researchers rarely sample and composite more than two samples per trench and rarely take duplicate profiles. However, if care is taken, there will be very little cross contamination and the data collected in terms of the depth profile will be more accurate.

Materials:

- Barrel auger – Standard Type No. R-HEO, 8.2 cm ID, with T-handle, Arts Machine Shop, American Falls, ID.
- Top soil cutters – 5, 10, 15 cm depth, 8.9 cm ID; made from 0.155-cm-thick cold-rolled steel; one end sharpened on a lathe, the other end fitted with a welded handle.
- Rubber mallet.

Procedures:

- Using the above procedure, a site can be sampled in two increments, 0-5 cm and 5-30 cm. This is useful in areas where most of the contamination is in the surface cut of the soil. In other sampling situations, using cores of 10- and 15-cm depth will provide incremental samples: 0-5, 5-10, 10-15, and 15-30 cm. When attempting this type of incremental sampling, attention must be given to two sources of error: contamination by fall-in of soil from the upper layers of more highly contaminated soil as the subsequent cores are taken from the hole and error in depth due to compaction.
- There is no simple, satisfactory way of sampling powdery, dry, loose, single grain soils by this core method. It is best to take samples when the soil has enough moisture to be coherent, even if this requires wetting the area to be sampled by sprinkling. An alternate method for sampling loose soils is to leave the corer in place and scoop out the contents.

4.9 Surface Water Sampling

Surface water refers to streams, rivers, lakes, ponds, etc. The term does not necessarily imply that the sample is collected from a shallow depth. Sampling locations will depend upon the objectives of the sampling program. For example, the objective may simply be to meet the requirements of regulatory agencies. Nevertheless, the purpose of water sampling is generally:

- To characterize the water quality. Samples may be taken in the mainstream of rivers, lakes, etc.
- To estimate the exposures to the public. In this case, the sampling sites will be at the point of exposure, e.g., recreational areas, public water supply intake, etc.
- To perform a long-term trend analysis. The sample may be taken at locations where long-term historical information is available.

4.9.1 Rivers, Streams, Creeks. In general, samples are required at points where the contaminant is well mixed and has the greatest cross section homogeneity. It is impossible to get representative samples near an out-fall (e.g., the release point). Indeed, mixing of the contaminant may not occur for substantial distances downstream. This is especially true for large, slow-moving rivers.

The best locations to sample are downstream of turbulence. The higher the water velocity, the greater the turbulence. Therefore, sampling should be downstream of falls, whitewater, or riffles where possible. Influxes of water into the stream/river being sampled can introduce heterogeneity into the cross sectional concentrations. As such, sampling should not be performed near the confluence with tributaries or point sources such as out-falls of industrial and municipal effluents.

Background samples are typically taken upstream of the facility discharge. Care must be exercised when this is done in rivers near the coast. Samples should be taken far enough upstream to avoid tidal influences.

Sampling in or near estuarine waters can be extremely difficult because the differences in temperature and density between fresh and salt water can result in substantial stratification.

Where the stream is relatively narrow, e.g., less than 20 feet across, and the water well mixed, one sampling point should suffice: at mid depth in the center of the stream. If the sample must be collected from the bank rather than midstream, it is best to collect the sample from the bank on the outside of a bend where the flow is greatest.

For larger and less well-mixed rivers, composite areal (as opposed to temporal) composites will be required. This will involve at least one vertical composite consisting of a sample collected just below the surface, a sample from mid depth, and a sample collected just above the bottom.

It is often recommended that three to five vertical composites be collected for a sample at a given position along a stream or river. Sometimes it is specified that these points be equidistant across the river. This may be fine in many cases, but the sampling points should reflect the river's volumetric flow.

4.9.2 Lakes and Ponds. These bodies of water experience less mixing and have a greater tendency to stratify than streams and rivers. As a result, a larger number of samples will be required. In a small impoundment or pond, a single vertical composite at the deepest point may be satisfactory. In a natural pond, this will usually be near the center. For a manmade body of water, the deepest point would be near the dam rather than the center. With lakes and large impoundments, several vertical composites will be required. They might be taken on a single or multiple transect or on a grid.

4.9.3 Surface Water Sampling Procedures. Sampling will usually be done from a boat, but it is sometimes possible to sample from the shore (or a bridge). Wading is to be avoided where possible. The only time wading is acceptable is in shallow, swiftly moving streams. In such a case, the sampler should make every effort to avoid disturbing the sediments and should also move upstream after entering the water and before sampling.

Dipping. The sample container itself can be simply submerged in the water. The container opening should be pointing upstream, and the whole process should be done carefully while disturbing the water as little as possible. Note, the container should be submerged; it should not be possible to collect surface debris. Obviously this cannot be done in very shallow bodies of water.

Subsurface Samplers. Subsurface grab samplers are available that use a technique very similar to that just described. In these devices a sealed bottle attached to a pole is lowered in the water to the appropriate depth. A control rod attached to the bottle cap is used to open the bottle and, after the bottle is filled, seal it.

Sample Containers. Collect a minimum of 2 liters, with the entire sample provided in one container. Use a plastic container, if at all possible. Suggested types include:

- Bottle, screw cap, collapsible, square, 1-gallon capacity, 12/pkg, FSN 6640-00-117-7855.
- Bottle, screw cap, collapsible, square, 1-quart capacity, 12/pkg, FSN 6640-00-117-8042.

Sample Site Selection:

- Choose an area that is open, not sheltered by trees or high brush, if possible.
- Consider the purpose of sampling when selecting a location, i.e., intake for drinking water, areas of access for farm animals.
- Avoid areas where surface debris could inhibit sampling.
- Avoid areas of high turbidity or high sediment, if possible.
- Inlet/outlet areas of water treatment plants may both need to be sampled. Samples from still water areas may also be required.
- Take sample from midstream, if possible.
- When a lake or reservoir is sampled, the sample should represent water that makes up the largest portion of the reservoir. Operating from bridges, docks, or boats may facilitate open-water collections.
- Avoid stirring up sediment and including it in the sample. Sample upstream if it is necessary to wade into the water. Sampling buckets should not be allowed to sink to the bottom.

Procedures:

- On the sample form, record the GPS reading, location, time, date, and other descriptive information.
- Use an indelible ink pen to record the sample number on the collection container.
- If the funnel and bucket have been previously used, they should be as clean as reasonably achievable.
- Set the sample container in a stable location on the ground with the funnel inserted in the opening.
- Stand downstream of bridges or structures.
- Lower the bucket into the main channel of stream, disturbing sediments and aquatic vegetation as little as possible.
- Collect a 3.5-L (1-gal) bucket of water and pour it into the sample container until the water in the container is within 2 cm (1 in.) of the top.
- Rinse the funnel and bucket with clean water.
- Dry the container with an absorbent towel.

4.10 Potable Water

When collecting from wells, the latter must be purged of 3-5 volumes of standing water in the well. As a rule, this may take 30 minutes. At a minimum, the nearest domestically used well down gradient from the discharge or contaminant source of interest should be sampled.

Materials:

- Bottle, screw cap, collapsible, square, 1-gallon capacity, 12/pkg, FSN 6640-00-117-7855.

Procedures:

- When collecting water from a tap, the tap should be directly connected to a main water line and should not be connected to a water storage tank.
- Remove aerator and strainers prior to sampling.
- Allow the cold water tap to run at least 2-3 min prior to sampling.
- Collect a minimum of 4 L, with the entire sample provided in one container. Use a plastic container, if at all possible.
- To avoid cross contamination, be sure to clean all sampling equipment with distilled water prior to acquiring additional samples.
- Preservative must be added to the sample no later than 5 days after the collection to ensure that the sample has pH 2 or less. To ensure that this requirement is accomplished, it is recommend that the sample be shipped next day air. Additionally, that lab should be notified that the sample is coming. If this is not possible, add 5 mL of concentrated nitric acid per liter of sample. This applies to all samples, except those analyzed for Rn-222 and H-3 that are collected in plastic or glass and sent to the laboratory.
- The USAFSAM laboratories do not maintain accreditation for safe drinking water analysis. Each state has its own accreditation requirements for SDWA. If you need to perform SDWA for radiological materials, then you should identify a local laboratory that is accredited in your state to perform the analysis. If you require assistance with sample procedures or identifying an accredited lab, contact Customer Service. ***Samples can still be sent for analysis, but they cannot be used for compliance.***

4.11 Vegetation and Foodstuffs

Although vegetation is not routinely obtained for analyses, collection of such samples should be made when the potential for food chain contamination justifies this. Vegetation growing on contaminated soil should be sampled and analyzed. Several kilograms of vegetation may be needed depending on the analytical sensitivities for the radionuclides of interest. The minimum sample volume is 3 liters of densely packed sample and should be double plastic bagged or packed in a 1-gallon wide-mouth plastic jar with screw cap.

In the event foodstuffs require collection, contact Customer Service for proper procedures.

4.12 Air Sampling

Filters and Flow Rates. The most frequently employed filter in environmental air sampling is the glass fiber filter. It is popular because it can maintain a low pressure drop even at the high flow rates and large dust loadings associated with environmental air sampling. The lower the pressure drop, the lower the work load on the air mover, and as a rule, the more accurate the flow meter reading. Cellulose (or paper) filters may also be used but are often less desirable.

- It is generally desirable to maintain a velocity across the face of the filter on the order of 20-50 cfm (keep in mind when calculating the face velocity that the effective sampling area is less than the overall size of the filter). Maintaining such velocities is especially important with cellulose filters, since a substantial decrease in collection efficiency can occur at low

velocities. High velocities are inappropriate with membrane filters due to the associated high pressure drop.

- If the flow rate decreases by more than 20% over the sampling period, it will be necessary to change the type of filter being used, reduce the flow rate, change the filter more frequently, or switch to a pump with a constant flow regulator.

Sampling Times. It is important that the times and dates for the beginning and end of each sampling period be as close as possible for all the sampling locations (including background). *It is critical that the sample time and flow rate or total sample volume be included on the sample form for all air samples.*

Sampling Duration. The minimum required sample time will be dependent upon the minimum detectable activity of the analysis method, the action level for the sample, and the flow rate. For unknown samples and during emergency response scenarios, a collection time of 1 hour is recommended but a minimum time of 20 minutes is typically required for most analysis methods. As a rule of thumb, a collection time of 20-60 minutes can be used with the Radeco if the nuclide is unknown.

Minimum Required Sampling Time

$$t_{min} = \frac{L_c \times 10}{Q \times DAC} \quad (20)$$

Where:
L_c = critical level for analysis method (Bq) (determined by the lab)
DAC = derived air concentration (Bq/m^3) from 10 CFR 20, Appendix B
Q = sampling flow rate (m^3/min)
1 ft^3 = 28.45 L = .02845 m3

Sample Collection. During collection, the sample should be disturbed as little as possible. This can be difficult if there is a strong wind, rain, snow, or below freezing temperatures. It is recommended that quick disconnect couplings be used with the filter holder/sampling head. If this is done, the entire sampling head (with the used filter and/or cartridge) can be transferred into a sealed plastic bag without the need to remove the filter in the field. A fresh sampling head is used to replace the old one.

Materials:

- AC generator (optional)
- High-volume air sampler
- Sampling tripod
- Sealable plastic bags
- Extension cord
- Forceps
- Sampling head
- Fuel
- Cellulose filters

- Cartridge
- Gloves

Procedures:

- Position the generator far enough away from the sampler and downwind so that exhaust fumes are not picked up by the sampler.
- Position the assembled sampling apparatus with air intake facing the source of the suspected airborne radioactive material release.
- The face of the sampler should be at breathing zone height, approximately 1.5 m (5 ft).
- To avoid effects of structurally induced turbulence, whenever possible the horizontal distance between the sampler and any structure should be equal to twice the height of the obstruction.
- Place a small "x" IN PENCIL ONLY on the outer edge of the "exposed" side of the filter paper. Carefully place the filter onto the sample head or sampling unit. Discard any damaged filter media (perforations, tears, folds, etc.).
- Avoid excessive tightening of the sample heads to prevent possible damage to the gasket. Turn the unit on and wait approximately 5 min before recording the initial flow rate. Determine the initial flow rate on the rotameter and record the flow rate and start time on the sample form.
- Run the sampler for the collection period.
- Prior to turning the sampler off, determine the ending flow rate.
- Turn off the sampler and record the ending flow rate and the time off on the sample form.
- Put on gloves.
- In a clean area if possible, using forceps remove the particulate filter carefully and place in a sealable plastic bag. Seal the bag. Decontaminate the forceps with clean water and dry. DO NOT FOLD FILTERS.
- Insert the sample filter ***unfolded*** into a plastic bag and then into an outer envelope for shipment. The outer envelope should be marked with the submitting base, the base sample number, and all other identifying information.
- Record any sign of damage to the filters, e.g., color or texture, and any sign of a deteriorating gasket indicated by blurring of the margins of the filter.
- Ensure AF Form 2753 accompanies the sample and includes the start and stop date and time, total sampling time, and volume of air sampled in cubic meters, corrected for standard conditions.

4.13 Other Materials

The Radioanalytical Lab performs radionuclide analysis on other types of samples such as industrial materials, biota, and/or chemicals. Specific instruction may be obtained by contacting Customer Service.

4.14 Special Considerations for Radiological Sample Shipping and Handling

4.14.1 Preservation. The specified analysis and the chemical characteristics of the radionuclide to be analyzed, as well as the objectives of the survey, determine sample preservation considerations. The purpose of preserving a sample is to maintain the sample in the condition needed for analysis between the time the sample is collected and the time that the sample is analyzed. Sample preservation should be coordinated with the analytical laboratory.

Many of the radiochemical species of interest behave like trace metals, and the preservation of water samples is easily achieved by acidification (EPA 1992e, 1992f). This prevents metallic species from depositing on the walls of the container. **It is the lab's policy that samples should not be preserved in this manner before shipment.** Any liquid samples should be shipped expeditiously to the lab for analysis. The sample will be preserved upon receipt. If shipment will take longer than 5 days to reach the lab, the sample should be preserved. Contact Customer Service for guidance.

The ***exceptions*** to this rule include:

- Samples for H-3, Rn-222, and C-14 analysis should never be preserved.
- Samples for analysis of isotopes with volatile oxidized forms (*e.g.*, ^{129}I, ^{131}I) should be collected and shipped as a stand-alone sample and should not be preserved. Add either sodium bisulfite or sodium metabisulfite as a holding reductant and ship without acidifying. Again it is recommended that such samples be preserved upon receipt at the lab. If other nuclides require analysis, collect separate sample and preserve to pH<1.
- For samples that may have organic compounds that could react with the acid, other methods of preservation should be evaluated.

4.14.2 Holding Time. Shipment to the lab should be expedited to minimize decay and/or surface plating before analysis. The lab should be consulted for any liquid sample that will require greater than 5 days to ship to the lab.

4.14.3 Temperature Control. None of the current methods used in the lab require temperature control. For urine samples, standard refrigeration should be used to control odors and bacteriological growth and reduce the formation of "phases" and solids from developing in the sample. Fecal samples should be frozen to control odor.

4.14.4 Packaging and Transporting Samples. All samples sent for analysis should be properly packaged before shipment. Visually inspect each sample container for indications of leaks or defects in the sample container.

- If needed, wipe individual sample containers with a damp cloth or absorbent paper to remove any exterior contamination.

- Place liquid sample containers inside individual plastic bags to reduce the chance for cross contamination and to contain the sample in case of leakage or breakage. Also include sufficient absorbent material to contain the liquid samples in case of leakage or breakage.
- Package sample containers to prevent breakage by immobilizing and isolating each sample container using packing material; this is especially important in cold weather, when plastic containers become brittle and water samples may freeze.
- Include the original, signed chain-of-custody form listing the samples in each package, i.e., if possible, avoid having multiple packages covered by a single chain-of-custody form.

APPENDIX A: PACIFIC COMMAND (PACAF)

Detachment 3 is a forward-based detachment of USAFSAM located at Kadena AB, Japan, servicing PACAF/PACOM operations. The Det 3 Analytical Division's mission is to perform lab analysis on a variety of media to support environmental and occupational hygiene programs. Det 3's Analytical Division's services include:

- Industrial Hygiene Analyses
- Environmental Analyses
- Drinking Water Analyses
- Bulk Materials
- Hazardous Waste
- Toxicity Characteristics Leachate Procedure
- Assistance Finding Specialized Analytical Options
- DHL Express Shipping Available Upon Request
- ESAM Budget Advisement
- Analytical Contract Laboratory Capabilities:
    - Japanese Commercial Laboratories
    - Korean Commercial Laboratories
    - U.S. Navy and U.S. Army Laboratories
    - U.S. Stateside Contract Commercial Labs

Det 3 is funded to cover the cost of in-house and contract analyses of Air Force industrial hygiene and environmental health samples. In addition, Det 3 offers a fee-for-service program for AF drinking water program analyses as well as non-Air Force Surgeon General funded programs. Contact Det 3 to obtain current pricing information as well as a list of contract laboratory points of contact.

Det 3 will accept sample submissions on the DOEHRS sample submission workbooks or using the Det 3 sample submission forms included in this guide. If you have any questions on how to complete the form, please call Customer Service.

A list of in-house Det 3 services is included in the appendix sample submission form and sampling analysis flow chart.

Det 3, USAF School of Aerospace Medicine
Analytical Division Unit 5213, Box 10
APO AP 96368-5213

ANALYTE	METHOD	MATRIX
Acidity	EPA 305.1	Water
Alkalinity	EPA 310.1	Water
Ammonia	US-696D-82X	Water
Anion Panel (Cl^-,F^-,SO_4^{2-})	EPA 300.0	Water
Bromide	EPA 300.0	Water
Chloride	EPA 300.0	Water
Conductivity	EPA 120.1	Water
Chromium VI	EPA 218.6	Water
Chromium VI	EPA 218.6	Salt Water
Chromium VI	NIOSH 7605	Air
COD	EPA 410.4	Water
Color	EPA 110.2	Water
Copper	EPA 200.7	Drinking Water
Flashpoint	SW 1010	Haz Waste Non-solid
Fluoride	EPA 300.0	Water
Hardness	EPA 200.7	Water
Lead	SW846 / 7000A	Paint
Lead	SW846 / 7000A	Wipe
Lead	SW846 / 7000A	Soil
Lead	EPA 200.7	Drinking Water
Langelier Saturation Index	Modified	Water
Mercury	EPA 245.2	Water
Mercury	EPA 245.2	Bulk
Mercury	EPA 245.2	TCLP

ANALYTE	METHOD	MATRIX
Metals in Water (20 analytes)	EPA 200.7	Water
Non Potable Water Prep	EPA 200.2	Water
Metals in Air (20 analytes)	NIOSH 7300	Air
Metals in Bulk (20 analytes)	EPA 6010B	Bulk
Bulk Prep	SW846	Bulk
Metals in TCLP (7analytes)	SW 6010/7470	Bulk
TCLP Prep	SW 1311	Bulk
Metals, RCRA (Total) (7analytes)	EPA 6010B	Bulk
Nitrate	EPA 300.0	Water
Nitrite	EPA 300.0	Water
Nitrate + Nitrite	EPA 300.0	Water
Orthophosphate	EPA 365.3	Water
PCB - Water	EPA 608/8082	Water
PCB - Oil	EPA 600/4-81-045	Oil
PCB - Soil	EPA 8082 (modified)	Soil
PCB - Wipe	EPA 8082 (modified)	Wipe
pH	EPA 150.1	Water
Phosphorous, Total	EPA 365.2	Water
TDS	EPA 160.1	Water
TSS	EPA 160.2	Water
Silica	US-696H-82W	Water
Solids (Total Residue)	EPA 160.2	Water
Sulfate	EPA 300.0	Water
Turbidity	EPA 180.1	Water

Det 3, USAF School of Aerospace Medicine
Analytical Division
Unit 5213, Box 10
APO AP 96368-5213
DSN 315-632-8349

REQUEST FOR LABORATORY SERVICES

Project Information

Date of Request	
Name Of Requester	
E-mail	
Organization	
Address Line 1	
Address Line 2	
Phone Number	
Fax	
Client Sample Number	
MIPR Number	

Sample Information

Sample Type	
Installation	
Location/Source	
Collected By	
Date/Time Collected	
Preservatives	
pH / Temperature	
Sample Category	

(Hazardous Waste, Drinking Water, Waste Water, Asbestos, PCB, Lead, Industrial Hygiene, etc.)

Turn-Around-Time

Routine (28 Days)	☐	Note: for expedited service (<28 days), customer must provide justification on the request form and coordinate with Det 3 prior to shipment.
Expedited Service	☐	

JUSTIFICATION:

Chain of Custody

Relinquished By/Time/Date		Relinquished By/Time/Date
Relinquished By/Time/Date		Relinquished By/Time/Date
Relinquished By/Time/Date		Relinquished By/Time/Date
Relinquished By/Time/Date		Relinquished By/Time/Date
Relinquished By/Time/Date		Relinquished By/Time/Date

Special Instructions

Analyses Requested (X all that apply)					
DW Inorganics		**WW Inorganics**		**WW Metals**	
Total Dissolved Solids		Acidity		Aluminum	
Conductivity		Alkalinity		Antimony	
Nitrate		Ammonia as N		Arsenic	
Fluoride		Bromide		Barium	
Chloride		Chloride		Beryllium	
Sulfate		Chromium VI		Boron	
Langelier Index		COD		Cadmium	
Aluminum		Color		Calcium	
Antimony		Conductivity		Chromium	
Arsenic		Fluoride		Cobalt	
Barium		Hardness		Copper	
Beryllium		Nitrate + Nitrite		Iron	
Boron		Nitrite		Lead	
Cadmium		Nitrate as N		Magnesium	
Calcium		ortho-Phosphorus		Manganese	
Chromium		Silica		Mercury	
Copper		Sulfate		Molybdenum	
Iron		Total Dissolved Solids		Nickel	
Lead		Total Phosphorus		Selenium	
Magnesium		Total Suspended Solids		Silver	
Manganese		Turbidity		Sodium	
Mercury		**Bulk & HW**		Strontium	
Nickel		Flash Point		Thallium	
Selenium		pH		Vanadium	
Silver		Lead (Bulk)		Zinc	
Sodium		TCLP-Metals			
Thallium		**Other Analyses/Special Instructions:**			
Zinc					
Organics					
PCB (Bulk)					
PCB (Oil)					
BTX					

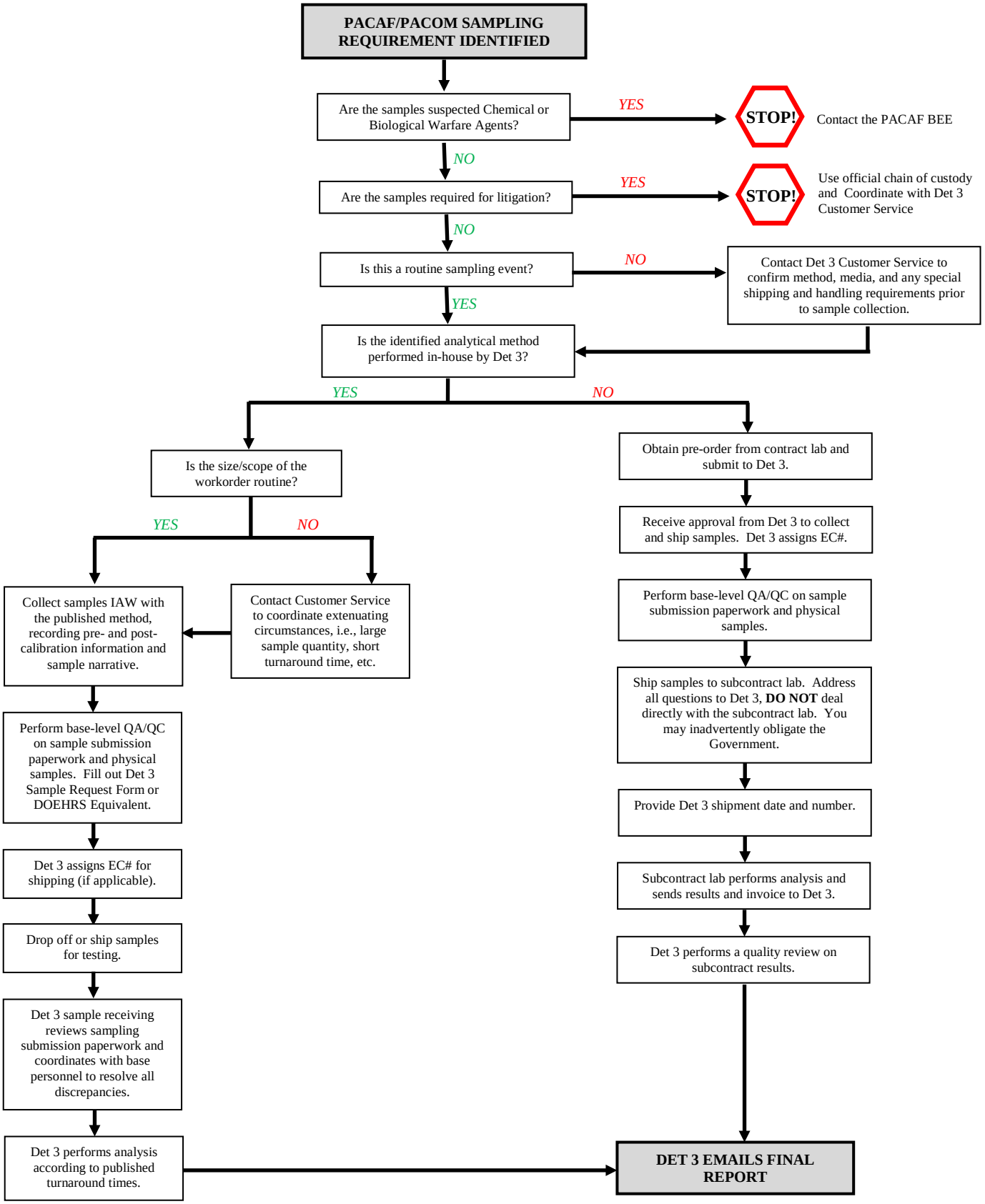


Figure A-1. USAFSAM Detachment 3 Sampling and Analysis Flowchart

APPENDIX B: AIR FORCE CENTRAL COMMAND (AFCENT)

Sampling support for the bases in the AFCENT Area of Responsibility is primarily provided by the USAPHC, formerly CHPPM-EUR. AFCENT BE personnel should refer to the *USAFCENT Deployed Bioenvironmental Engineering (BE) Guide*. It is best to sample on Sunday or Monday and ship immediately so that is it is received before the weekend. This reduces the likelihood of exceeding holding times and storage temperatures. USAPHC-Europe recommends you first contact FedEx®, DHL Worldwide®, and UPS® to determine which carrier serves your particular location.

USAPHC-Europe Procedures

Consult the USAPHC-Europe DLS Customer Guide to determine media and container selection, holding times, and sample preparation issues. If you have any questions, immediately contact the customer service section at DSN 314-486-8381/7053/7744 for guidance. If emailing your questions or concerns, please use the DLS Customer Hotline email [usachppmeur.dlshotline@amedd.army.mil]. This hotline is available to all DLS staff members and is checked several times during the day.

A Request for Services form ***must*** be completed ***prior*** to sending samples to USAPHC-Europe. For the most current copy of USAPHC-Europe forms, refer to the DLS Customer Guide. Fax forms to the Customer Service Division (CSD) at DSN 314-486-7054. This same process can be used to order sample kits. CSD can provide sampling containers with the exception of IH media. Always provide your civilian mailing address and phone number if possible, as they try to send all sampling kits and reports via commercial couriers (this cost is covered by the MOA AFCENT has with USAPHC-Europe).

Wait for the division chief (either Organic or Inorganic) to accept (or reject) your request via email. If there is a scheduling problem, they will work with you and may change your collection and submission date. CSD will notify you when the request is accepted.

If your request for services is accepted, complete CSD Form 2 or 3 to send with your sample. If USAPHC-Europe is unable to conduct the requested analyses, contact the AFFOR BE to find another lab to conduct the analysis or a sampling method that USAPHC-Europe will support.

Package and ship your sample via contract carrier. Include the CSD Form 2 or 3 with your sample. To assist the Traffic Management Office or U.S. Army Combat Cargo Officer in verifying shipments to USAPHC-Europe DLS are U.S. Forces owned, please insert the Department of Defense Address Activity Code (DODAAC) in the commercial address as follows:

USAPHC-Europe, Department of Laboratory Sciences
DODAAC – WK4UPX
Kirchberg Kaserne Gebaude 3809, Raum 110
D-66849 Landstuhl, Germany
Phone (Civilian): 06371-86-7052 *(Note: Your logistics section will know your DODAAC)*

Email the carrier tracking number (or air bill information) to the DLC Customer Hotline email so they can track the sample. Please provide the airway bill number for DHL and FedEx® and the TCN and Mission number for AMC shipments so they can track them. Historically, TNT and UPS have not met their contractual requirements regarding shipping times and handling and should be used with caution.

USAFSAM may also be able to provide sample analysis support in the event USAPHC-Europe is unable to meet your analytical needs. Contact the AFCENT BE to formally request use of USAFSAM services.

Notify the AFCENT BE or AFFOR BEM immediately of any exposures that exceed an occupational and environmental action level or exposure standard.

APPENDIX C: SUMMARY OF IH/EH SERVICES

Table C-1 is a list of AIHA-IHLAP and ELLAP accredited in-house analytical services. The list below represents accredited fields of testing but is not all inclusive for services provided by the Industrial Hygiene and Environmental Chemistry lab. For analytical services not listed below, please refer to ASAGE or Customer Service.

Table C-1. Summary of USAFSAM/OEA, AIHA-IHLAP, and ELLAP Accredited Analytical Services

Scope Category	Field of Testing	Published Reference Method				
IHLAP Chromatography Core	Gas Chromatography (GC)	NIOSH 1000 NIOSH 1003 NIOSH 1004 NIOSH 1005 NIOSH 1006 NIOSH 1007 NIOSH 1010 NIOSH 1011 NIOSH 1014 NIOSH 1019 NIOSH 1020 NIOSH 1022 NIOSH 1300 NIOSH 1301 NIOSH 1400 NIOSH 1401 NIOSH 1402 NIOSH 1403	NIOSH 1404 NIOSH 1450 NIOSH 1451 NIOSH 1452 NIOSH 1453 NIOSH 1454 NIOSH 1457 NIOSH 1458 NIOSH 1459 NIOSH 1500 NIOSH 1501 NIOSH 1550 NIOSH 1552 NIOSH 1600 NIOSH 1602 NIOSH 1603 NIOSH 1604 NIOSH 1606	NIOSH 1608 NIOSH 1609 NIOSH 1610 NIOSH 1611 NIOSH 1613 NIOSH 1616 NIOSH 1617 NIOSH 1619 NIOSH 1620 NIOSH 2000 NIOSH 2003 NIOSH 2004 NIOSH 2005 NIOSH 2007 NIOSH 2010 NIOSH 2500 NIOSH 2501 NIOSH 2505	NIOSH 2508 NIOSH 2513 NIOSH 2516 NIOSH 2519 NIOSH 2521 NIOSH 2527 NIOSH 2528 NIOSH 2529 NIOSH 2530 NIOSH 2536 NIOSH 2537 NIOSH 2538 NIOSH 2541 NIOSH 2542 NIOSH 2545 NIOSH 2546 NIOSH 2551 NIOSH 5020	NIOSH 5021 NIOSH 5034 NIOSH 5037 NIOSH 5038 NIOSH 5515 NIOSH 5518 NIOSH 5523 NIOSH 5600 NIOSH S-227 OSHA 101 OSHA 103 OSHA 106 OSHA 99 OSHA PV2042 OSHA PV2091
	GC-Diffusive Sampler	NIOSH 1000 NIOSH 1003 NIOSH 1004 NIOSH 1005 NIOSH 1006 NIOSH 1007 NIOSH 1010 NIOSH 1011 NIOSH 1014 NIOSH 1019 NIOSH 1020 NIOSH 1022 NIOSH 1300 NIOSH 1301 NIOSH 1400 NIOSH 1401	NIOSH 1402 NIOSH 1403 NIOSH 1450 NIOSH 1452 NIOSH 1453 NIOSH 1454 NIOSH 1457 NIOSH 1458 NIOSH 1459 NIOSH 1500 NIOSH 1501 NIOSH 1550 NIOSH 1600 NIOSH 1602 NIOSH 1604	NIOSH 1608 NIOSH 1609 NIOSH 1610 NIOSH 1611 NIOSH 1616 NIOSH 1617 NIOSH 1620 NIOSH 2004 NIOSH 2500 NIOSH 2508 NIOSH 2513	NIOSH 2529 NIOSH 2537	OSHA PV2091
	Ion Chromatography	NIOSH 7605				
	Liquid Chromatography	NIOSH 2016 NIOSH 2532	OSHA 64 OSHA 10076			
IHLAP and ELLAP Spectrometry Core	ICP-IHLAP	NIOSH 7300				
	ICP-ELLAP	*Airborne Dust:*	NIOSH 7300			
		Paint:	EPA SW-846 6010C			
		Settled Dust by Wipe:	EPA SW-846 6010C			
		Soil:	EPA SW-846 6010C			
Miscellaneous Core	Gravimetric	NIOSH 0500 NIOSH 0600				

APPENDIX D: BIBLIOGRAPHY

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U.S. Environmental Protection Agency. *Guidance on Choosing a Sampling Design for Environmental Data Collection*, EPA QA/G-5S. Washington, DC: Office of Environmental Information, Dec 2002. Retrieved 5 Dec 2011 from http://www.epa.gov/quality/qs-docs/g5s-final.pdf.

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APPENDIX E: DOEHRS TUTORIAL

E.1 DOEHRS Sample Submission Procedures

The standard sample submission forms are the DOEHRS Discoverer Viewer *USAFSAM Sample Submission* workbooks (Figure F-1). These should be used in place of the outdated AF Form 2750 series documents. If difficulties arise during printing from Discoverer Viewer, a blank discoverer submission form may be used and the DOEHRS sample numbers transcribed to the form.

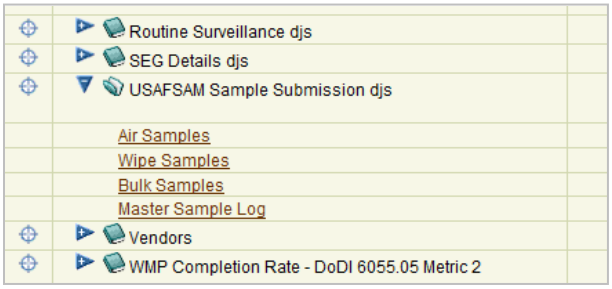

Figure E-1. USAFSAM Sample Submission Workbook

Click on the applicable workbook for your type of sample, i.e., air, wipe, or bulk. Enter your base name and sample collection dates on the following screen (Figure F-2):

Figure E-2. Sample Submission Workbook Query

The following screen will appear listing all samples collected on the date requested (Figure F-3). To print the page, click *Printable page* under the actions menu on the left hand side.

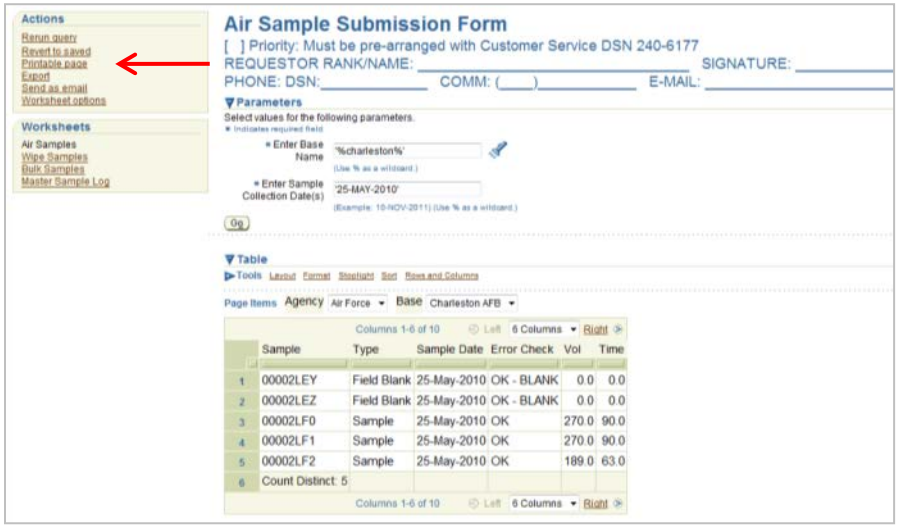

Figure E-3.– Query Results

Next, click *Page Setup* and adjust the settings until the sample results fit on one page from left to right. Follow the printing directions indicated in discoverer viewer to ensure the report prints 1-page wide. The final report should look similar to the example below (Figure F-4):

Air Sample Submission Form

[ ] Priority: Must be pre-arranged with Customer Service DSN 240-6177

REQUESTOR RANK/NAME: *SrA John Doe* SIGNATURE: *SrA John Doe*

PHONE: DSN: *798-5555* COMM: (*938*) *938-5555* E-MAIL: *john.doe@us.af.mil*

Agency: Air Force | Base: Charleston AFB

	Sample	Type	Sample Date	Error Check	Vol	Time	CAS		Display Method Name	Display Hazard Name
1	00002LEY	Field Blank	25-May-2010	OK - BLANK	0.0	0.0	18540-29-9		NIOSH 7605	CHROMIUM(VI)
2	00002LEZ	Field Blank	25-May-2010	OK - BLANK	0.0	0.0	18540-29-9		NIOSH 7605	CHROMIUM(VI)
3	00002LF0	Sample	25-May-2010	OK	270.0	90.0	18540-29-9		NIOSH 7605	CHROMIUM(VI)
4	00002LF1	Sample	25-May-2010	OK	270.0	90.0	18540-29-9		NIOSH 7605	CHROMIUM(VI)
5	00002LF2	Sample	25-May-2010	OK	189.0	63.0	18540-29-9		NIOSH 7605	CHROMIUM(VI)
6	Count Distinct: 5									

Enter Comments/Remarks to Lab Here:

Please CC TSgt Jane Smith on final results.

Figure E-4. Example DOEHRS Sample Submission Form

In the event Discoverer Viewer is not working properly, the blank form (Figure F-5) on the following page may be used for sample submissions. Shipping samples to the lab should not be delayed if issues are encountered entering data into DOEHRS or retrieving data from Discoverer Viewer. This should be the exception; bases should strive to submit samples to USAFSAM using the auto-generated discoverer viewer workbook.

Air Sample Submission Form

[ ] Priority: Must be pre-arranged with Customer Service [DSN 798-2523 / COMM (937) 938-2523]

REQUESTOR RANK/NAME: _____ SIGNATURE: _____

PHONE: DSN:_____ COMM: (____)_____ E-MAIL: _____

Agency: Air Force | Base:

	Sample	Type	Sampling Media	Sample Date	Error Check	Vol	Time	CAS		Display Method Name	Display Hazard Name
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

Enter Comments/Remarks to Lab Here:

Figure E-5. Blank Discoverer Viewer Sample Submission Form

E.2 Air Sampling Media in DOEHRS

It is important to indicate the type of media actually used during your sampling event. This is accomplished in DOEHRS during the sampling method selection. In the example below (Figure F-6), lead has been selected as the analyte of concern, and the following list of methods is provided by DOEHRS. Notice multiple NIOSH 7300 methods are listed, each with a different media.

Select	Sampling Methods
○	NIOSH 7082 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 7105 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 7700 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 7701 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 7702 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 8003
○	NIOSH 9100 Bulk/Disposable towellettes moistened with wetting agent
○	OSHA 125 Navy Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	OSHA 206 Navy Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
◉ ←	NIOSH 7300 Air/FILTER (0.8-um MCEF membrane, 37mm diameter)
○	NIOSH 7300 Air/FILTER (5-um PVC membrane)
○	NIOSH 7300 Air/IOM 0.8 um MCEF
○	NIOSH 7300 Air/IOM (5-um PVC membrane)
○	EPA 7000B Bulk/Paint Chip
○	No Sampling Method

Figure E-6. Air Sampling Methods and Associated Media

Once a method is selected, the associated media is pulled into the sampling event (Figure F-7):

General Sample Information	
Shop	TRH Welding (FFCH4)
SEG	TRH Welding
Sample Date	2011/11/10 (yyyy/mm/dd)
Mission ID	
Sampling Method	NIOSH 7300
Sampling Media	FILTER (0.8-um MCEF membr
Sampling Media Expiration Date	2012/05/25 (yyyy/mm/dd)

Figure E-7. Annotating Media in General Sample Information Screen

E.3 Air Sampling Pump Pre- and Post-Calibration in DOEHRS

The flow rate difference of the pre- and post-calibration flow rates is automatically calculated by DOEHRS (Figure F-8). Values greater than 5% are flagged with the >5 red icon.

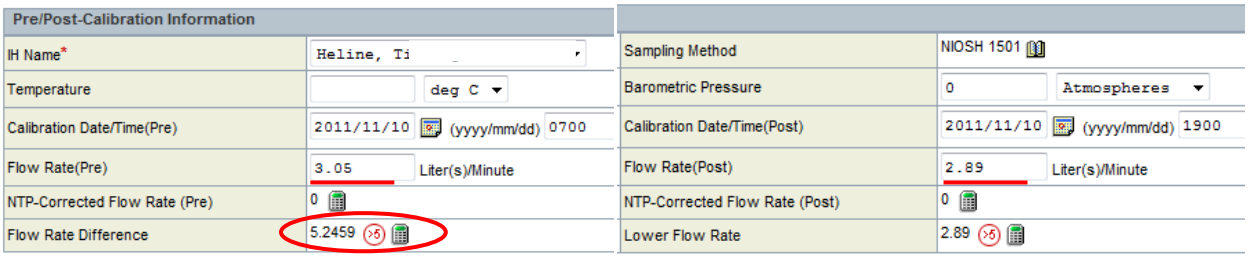

Figure E-8. Flow Rate Difference

E.4 Normal Temperature and Pressure Corrections in DOEHRS

NTP corrections are automatically calculated by DOEHRS when the temperature and pressure are provided in the pre- and post-calibration screen (Figure F-9). Do not change the default values; by doing so you may inadvertently alter the sample volume reported to the lab. Volumes reported to the lab should be sample volumes at site temperature and pressure conditions (not corrected to NTP). Refer to the discussion in Section 2.9 for additional information.

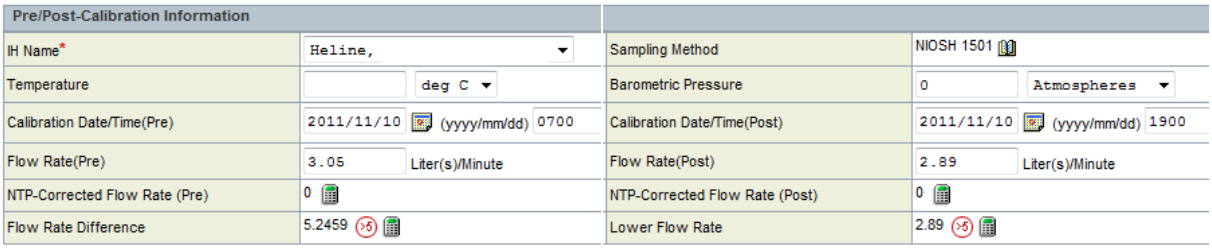

Figure E-9. NTP Corrections

E.5 Generating a Blank Sample Report Form

Blank sample report forms can be printed from DOEHRS and used to annotate field notes when conducting air sampling operations (Figure F-10). Start by locating your master schedule task for the planned air sampling event. Click the "Other Actions" dropdown box and select "Generate Blank Sample Report Form." The final step is to export to PDF and print the document.

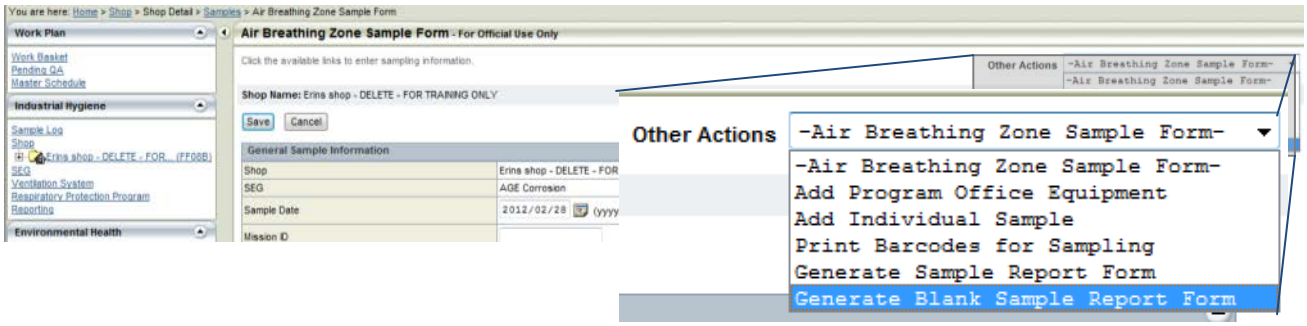

Figure E-10. Generating Blank Sample Report Forms

E.6 Selecting Blanks and Documenting Blank Corrections in DOEHRS

Blank samples should be indicated in DOEHRS using the appropriate dropdown menu (Figure F-11). For additional information on types of blanks, refer to Section 2.11.

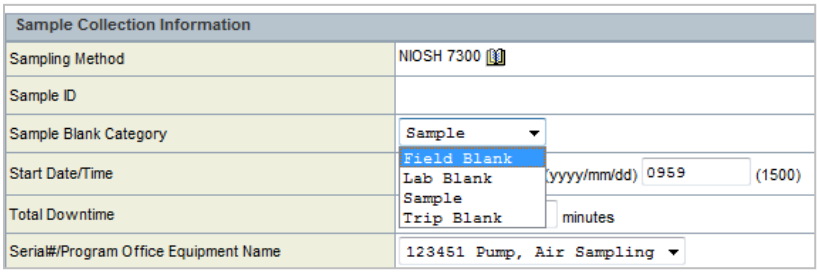

Figure E-11. Blank Selections

Blank corrections should be documented when recording sample results in DOEHRS. See below for how the example in Section 2.12 should be recorded in DOEHRS (Figure F-12). Pay attention to units when recording results. The method detection limit/limit of detection will be listed as the *Reporting Limit* on USAFSAM in-house sample reports and will usually be reported as mass/sample (i.e., µg/filter).

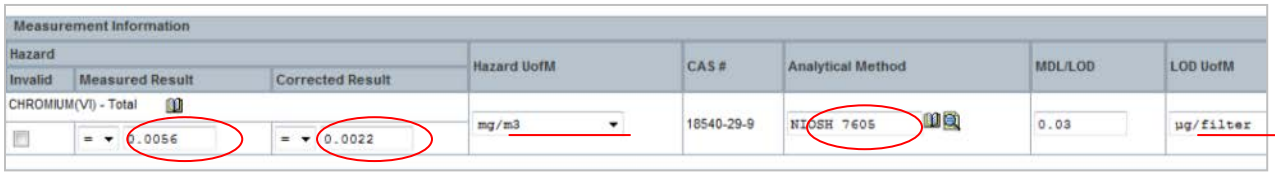

Figure E-12. Blank Corrections

E.7 TWA Calculations

When calculating TWAs in DOEHRS, the user must make an assumption regarding the unsampled period of the work shift (Figure F-13). By selecting *Equals Zero*, the user assumes the employee is only exposed to the contaminant during the sampled portion, and Equation 7 is used to calculate the TWA. Selecting *Equals Sampled Period*, the user assumes the employee exposure during the unsampled part of the work is equal to the average of the sampled period, and Equation 9 is used to calculate the TWA. The third option, *Equals [ ] mg/m*^{3}, may be used if the unsampled exposure is estimated using another method.

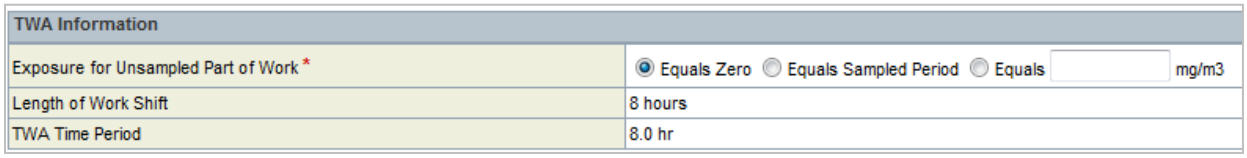

Figure E-13. Time-Weighted Average Calculations

E.8 Sampling and Analytical Error

For most analytical methods listed in DOEHRS, the published sampling and analytical error (CV_T or S_{rT}) has been included in the DOEHRS tables. When known, these published error values are used for subsequent calculations including UCL and LCL. For the methods without a published CV_T or S_{rT}, the actual sampling precision/error should be entered in DOEHRS. The example below is a screen shot captured during a TWA calculation for sampling by NIOSH 7300 for lead, which does not have a published S_{rT} (Figure F-14). The user has the opportunity to provide S_{rT}, S_r, or SAE values. Below, the SAE value from the example in Section 2.14 was used.

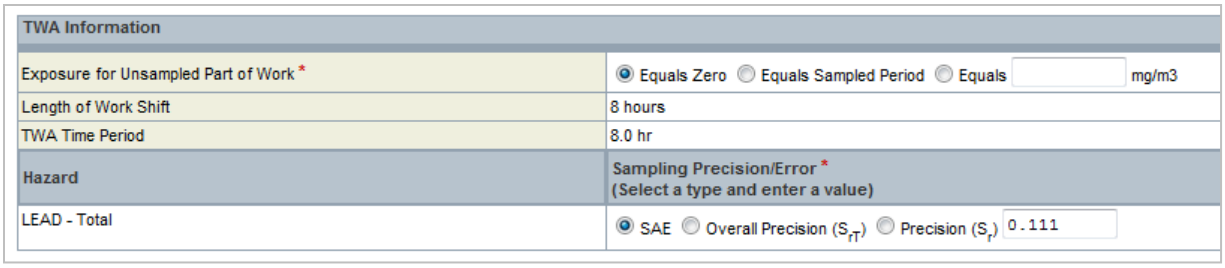

Figure E-14. Sampling and Analytical Error

E.9 Upper and Lower Confidence Limits

UCLs are calculated by DOEHRS using the published or user-provided sampling precision/error values. The UCL is always listed in the *Air Breathing Zone TWAs* table (Figure F-15).

Figure E-15. UCL Calculations Shown on TWA Tables

Additionally, once six samples have been collected, an Industrial Hygiene SEG Assessment may be completed using normal distribution statistics (Figure F-16). These statistics allow you to adjust the confidence interval and percentile for the UCL as well as several additional statistics. The default UCL settings are set at 95% UCL 95th percentile in accordance with the OSHA Technical Manual.

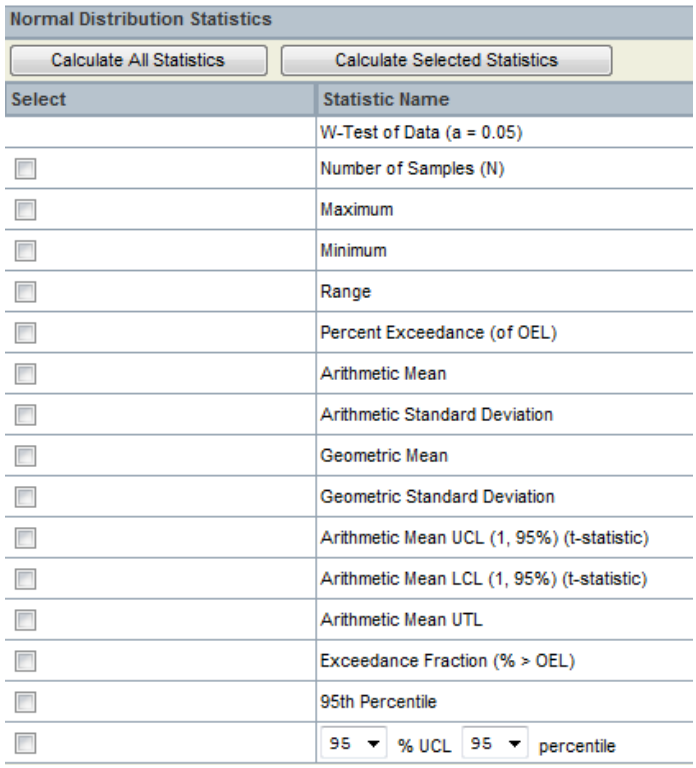

Figure E-16. Available Statistical Analyses in IH Assessments

E.10 Extended Work Shifts

DOEHRS can calculate OEEL adjustments automatically using either the Brief and Scala or OSHA (Figure F-17). For extended work shifts greater than 8 hours, the screen shot in Figure F-18 will appear when calculating TWAs. The user must chose *Do Not Adjust, Brief and Scala,* or *OSHA* prior to proceeding with the TWA calculation. As stated in Section 2.17, the Brief and Scala method is the preferred method for adjusting OEELs. The user is also required to define the exposure as day-to-day or present through the full work week. If the later is true, the number of days in the work week must also be defined by the user.

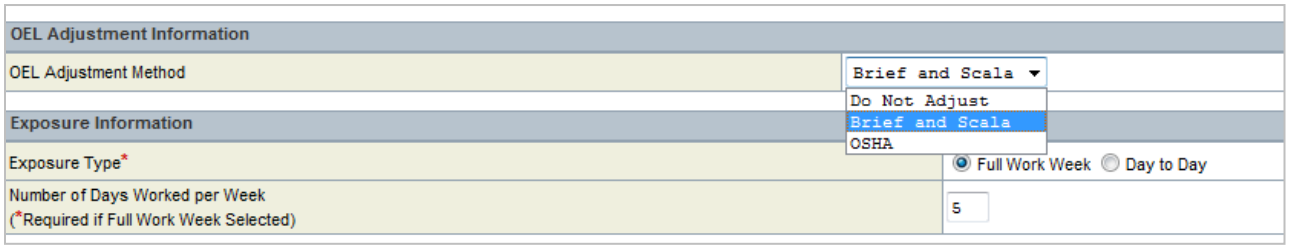

Figure E-17. OEEL Adjustments for Extended Work Shifts

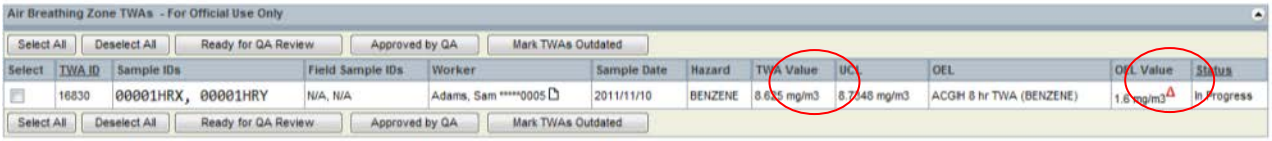

Figure E-18. TWA Adjustments for Extended Work Shifts

APPENDIX F: LISTS OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AFCENT	Air Force Central Command
AFI	Air Force Instruction
AFMAN	Air Force Manual
AFRRAD	Air Force Radioactive Recycling and Disposal
AIHA	American Industrial Hygiene Association
AL	action level
ALI	annual limits of intake
AMAD	activity median aerodynamic diameter
AOC	area of concern
ASAGE	Automated Sampling Guide
ASTDR	Agency for Toxic Substance and Disease Registry
ASTM	American Society for Testing and Materials
B	bias
BE	bioenvironmental engineering
BPA	blanket purchase agreement
C	ceiling
CAA	Clean Air Act
CO	carbon monoxide
COC	chain-of-custody
Cr(VI)	hexavalent chromium
CS	Customer Service
CSD	Customer Service Division
CV_P	pump coefficient of variation
CV_T	total coefficient of variation
CWA	Clean Water Act
DAC	derived air concentration
Det 3	Detachment 3, Kadena AB, Japan
DHP	Defense Health Programs
DI	deionized water
DOEHRS	Defense Occupational and Environmental Health Readiness System
DOT	Department of Transportation
DPS	deployable particulate sampler
DQA	data quality assessment
DQO	data quality objectives
EDS	energy dispersive spectroscopy
EH	environmental health

EL	excursion limit
ELLAP	Environmental Lead Laboratory Accreditation Program
EPA	Environmental Protection Agency
ESOH	environment, safety, and occupational health
FID	flame ionization detector
GC	gas chromatography
GLD	generally licensed device
HAP	hazardous air pollutant
HCl	hydrochloric acid
HDI	hexamethylene diisocyanate
HNO_3	nitric acid
HRA	health risk assessment
IATA	International Air Transport Association
ICE	Interactive Customer Evaluation
ICP	inductively coupled plasma
ID	identification
IHLAP	Industrial Hygiene Laboratory Accreditation Program
IHSTAT	AIHA free spreadsheet on industrial hygiene statistics
IOM	Institute of Occupational Medicine
IPDI	isophorome diisocyanate
IRIS	Integrated Risk Information System
LCL	lower confidence limit
LIMS	Laboratory Information Management System
LRN	Laboratory Response Network
LSC	liquid scintillation counting
MC	materials characterization
MCE	mixed cellulose ester
MCL	maximum contaminant level
MDA	minimum detectable activity
MDI	methylene diphenyl diisocyanate
MEG	Military Exposure Guideline
MRL	minimum risk levels
MS	mass spectrometry
MSDS	material safety data sheet
NAAQS	National Ambient Air Quality Standards
NIOSH	National Institute for Occupational Safety and Health
NMAM	NIOSH Manual of Analytical Methods
NPDES	National Pollutant Discharge Elimination System
NTP	normal temperature and pressure
OCONUS	Outside the contiguous United States

OEA	Occupational and Environmental Analytical Services Division
OEEL	occupational and environmental exposure limit
OEH	occupational and environmental health
OEHSA	occupational and environmental health site assessment
OES	optical emission spectrometry
OSHA	Occupational Safety and Health Administration
P	pressure
PACAF	Pacific Air Forces
Pb	lead
PCB	polychlorinated biphenyl
PCM	phased contrast microscopy
PEL	permissible exposure limit
PLM	polarized light microscopy
PM	particulate matter
PPE	personal protective equipment
PTFE	polytetrafluoroethylene (Teflon) filter
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
S_{rT}	overall precision
SAE	aampling and analytical error
SAED	selected area electron diffraction
SAM	sampling, analysis, and monitoring
SDWA	Safe Drinking Water Act
SEG	similar exposure group
SEM	scanning electron microscopy
SSDR	Sealed Source Device Registry
SSN	Social Security number
STEL	short-term exposure limit
SVOC	semi-volatile organic compound
T	temperature
TAT	turnaround time
TDI	toluene diisocyanate
TEM	transmission electron microscopy
TLV	threshold limit value
TSCA	Toxic Substance Control Act
TSP	total suspended particulate
TWA	time-weighted average

U	uncertainty
UCL	upper confidence limit
USAFSAM	United States Air Force School of Aerospace Medicine
USAPHC	United States Army Public Health Command (formerly CHPPM)
VOA	volatile organic analysis
VOC	volatile organic compounds
VSP	Visual Sample Plan
WPAFB	Wright-Patterson Air Force Base
Y	exposure severity

APPENDIX G: INDUSTRIAL HYGIENE EQUATIONS

1. Pump Flow Rate Difference	$\frac{(\textbf{pre} - \textbf{calibration flow rate}) - (\textbf{post} - \textbf{calibration flow rate})}{(\textbf{pre} - \textbf{calibration flow rate})} \times \mathbf{100}$
2. Sample Collection Time	$\text{Air Sampling Time (min)} = \frac{\text{Volume (L)}}{\text{Flow Rate (LPM)}}$
3. Minimum Air Volume	$\text{Minium Air Volume (L)} = \frac{\text{RL}}{(\text{OEEL}) \times (\text{Desired Fraction})}$
4. Blank Corrections	$\text{Blank Corrected Result } \left(\frac{\text{mg}}{\text{m}^3}\right) = \frac{[\text{Field Result } (\mu\text{g})] - \text{ avg}[\text{Blank Results } (\mu\text{g})]}{\text{Sample Volume (L)}}$
5. 8-h TWA, Unsampled Portion Equals Zero	$\text{TWA}_{8\text{h}} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{480 \text{ min}}$
6. TWA-STEL	$\text{TWA}_{15 \text{ min}} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{15 \text{ min}}$
7. 8-h TWA or 15-min STEL, Unsampled Portion Equals Avg Concentration	$\text{TWA} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{T_1 + T_2 + \ldots + T_n}$
8. OSHA Sampling and Analytical Error	$\text{SAE} = CV_T \text{ X } 1.645$
9. NIOSH Sampling and Analytical Error	$\text{SAE} = S_{rT} \text{ X } 1.645$
10. SAE Using Laboratory Method Uncertainty	$\text{SAE} = \sqrt{(CV_A)^2 + (CV_P)^2} \text{ X } 1.645$
11. Analytical Coefficient of Variation (USAFSAM/OEA chemistry lab results only)	$CV_A = \frac{\frac{U}{2}}{100+B}$
12. Exposure Severity	$Y = \frac{X}{\text{OEEL}}$
13. Full Period, Continuous Single Sample $LCL_{95\%}$ and $UCL_{96\%}$	$LCL_{95\%} = Y - \text{SAE}$ $UCL_{95\%} = Y + \text{SAE}$
14. Full Period, Consecutive Sampling $LCL_{95\%}$ and $UCL_{96\%}$	$LCL_{95\%} = Y - \frac{\text{SAE}\sqrt{(T_1X_1)^2 + (T_2X_2)^2 + \cdots + (T_nX_n)^2}}{\text{PEL}\,(T_1 + T_2 + \cdots + T_n)^2}$ $UCL_{95\%} = Y + \frac{\text{SAE}\sqrt{(T_1X_1)^2 + (T_2X_2)^2 + \cdots + (T_nX_n)^2}}{\text{PEL}\,(T_1 + T_2 + \cdots + T_n)^2}$
15. Flow Corrections for Temperature and Pressure	$Q_{\text{Field}} = Q_{\text{Cal}} \sqrt{\frac{P_{\text{cal}}}{P_{\text{Field}}} \times \frac{T_{\text{Field}}}{T_{\text{cal}}}}$
16. Unit Conversions	$\text{mg/m}^3 = (\text{ppm}) \times \frac{\text{Molecular Weight of Contaminant of Concern}}{24.45}$
17. Equivalent Exposure Severity for a Mixture	$Y_{\text{mixture}} = \frac{C_1}{\text{OEEL}_1} + \frac{C_2}{\text{OEEL}_2} + \cdots + \frac{C_n}{\text{OEEL}_n}$
18. Brief and Scala Method, Work Week Less Than 7 Days	$\text{Adjusted OEEL} = \text{OEEL} \times \left(\frac{8}{h} \times \frac{24-h}{16}\right)$
19. Brief and Scala Method, 7-Day Work Weeks	$\text{Adjusted OEEL} = \text{OEEL} \times \left(\frac{40}{h} \times \frac{168-h}{128}\right)$
20. Conversion of Sample Results from an Element to a Compound	$RC = RR \times \frac{MWC}{MWE}$
21. Minimum Required Radiological Sampling Time	$t_{\text{min}} = \frac{L_c \times 10}{Q \times DAC}$

APPENDIX H: RADIOLOGICAL SAMPLE FORMS

USAFSAM is currently reviewing the possible use of DOEHRS forms for radiological sample submissions. Currently, AF Form 2753 is the preferred sample form. AF Form 495 (envelope) is now considered obsolete. Swipe samples should be submitted in a plastic bag and an AF Form 2753 completed for each sample.

Instructions for Completing AF Form 2753

The purpose of this form is to record collection information for radiological samples. The front side (Part 1) of the 2753 is submitted for environmental samples, while the reverse side (Part 2) is used for biological samples. This form is available on the Air Force e-Publishing website.

For environmental samples, Table H-1 on the following page describes the appropriate entries for the various fields on AF Form 2753. If you are completing AF Form 2753 for biological samples, please use the guidance in Table H-2.

Table H-1. AF Form 2753, Environmental Radiological Samples

FIELD	DESCRIPTION
Workplace or Site Identifier	Enter code for Workplace Identifier (if industrial sample) or Site Identifier (if environmental sample).
Base	Enter name of base where workplace is located.
Organization	Enter name of organization.
Workplace or Site	Enter name of workplace or site.
Building Number/Location	Enter building number or location.
Room/Area	Enter specific part of workplace being sampled (e.g., Room 26, specimen handling table). If sample pertains to entire workplace, enter "NA."
Date Collection Began	Enter date sample was collected or date sampling began (e.g., 20120114).
Time Collection Began	Enter local time (24-hour clock) when sampling began.
Date Collection Ended	Enter date sample was collected or date sampling ended (e.g., 20120115).
Time Collection Ended	Enter local time (24-hour clock) when sampling ended.
Mail Reports To	Your office or organization. Enter the mailing code (base code) for your particular facility, consisting of an alphabetical prefix, a number, and a suffix. If you are unsure of your correct mailing code, please call the laboratory. Failure to provide the proper mailing code may cause your report to be misrouted or delayed in processing. Include a responsible person and an alternate that can answer questions from the lab concerning the sample.
Copies To	You can enter up to two additional address codes for duplicate copies of the reports, and we will mail them directly to your intended recipients (e.g., the Command BE, Base Civil Engineering, etc.). If you wish to do this, please call us prior to the first time, so that we can make sure your intended recipient is in our database and give you the correct address code to use.
Sample Collected By	Enter name (last name, first name, middle initial), grade, and AFSC of individual collecting the sample.
Signature	Enter the signature of the individual collecting the sample.
DSN	Enter DSN of responsible individual who can answer questions that may arise from the lab concerning the sample.
Reason for Submission	Select and enter code (from the boxes to the right) indicating the reason for submission. If "other" is chosen, please specify the reason.
Base Sample Number	Enter the eight-digit coded base sample number or DOEHRS sample ID.
Analysis Requested	Specify the analysis you require. Be as specific as possible. If unsure, contact the lab for guidance. Include any special analysis requests as well or special data requirements. For example, please analyze by alpha spectroscopy for ^{234}U, ^{235}U, and ^{238}U to distinguish naturally occurring uranium from depleted uranium contaminant. Acceptable requests include: - Gamma spectroscopy - Alpha spectroscopy for a specific alpha emitter - Gross alpha/beta - LSC analysis for H-3, C-14, Ni-63 - Analysis for a specific isotope, e.g., Cs-137 For field blanks be sure to indicate this and for which sample(s) the blank is for. Analysis requested for the blank should be the same as other samples. If you are unsure of the analysis needed, contact the lab.
Air Filter Data	Enter the volume of air collected on the air filter (air samples only). Use cubic meters (m^3) if possible. If another unit of volume is used, please indicate the volumetric unit (i.e., ft^3).
Comments	For swipe samples, list the area swiped in the comments field of AF Form 2753.

Table H-2. AF Form 2753, Biological Radiological Samples

FIELD	DESCRIPTION
Workplace or Site Identifier	Enter code for Workplace Identifier (if industrial sample) or Site Identifier (if environmental sample).
Base	Enter name of base where workplace is located.
Organization	Enter name of organization.
Workplace or Site	Enter name of workplace or site.
Building #/Location	Enter building number or location.
Room/Area	Enter specific part of workplace being sampled (e.g., Room 26, specimen handling table). If sample pertains to entire workplace, enter "NA."
Date Collection Began	Enter date sample was collected or date sampling began (e.g., 20120114).
Time Collection Began	Enter local time (24-hour clock) when sampling began.
Date Collection Ended	Enter date sample was collected or date sampling ended (e.g., 20120115).
Time Collection Ended	Enter local time (24-hour clock) when sampling ended.
Mail Reports To	Your office or organization. Enter the mailing code (base code) for your particular facility, consisting of an alphabetical prefix, a number, and a suffix. If you are unsure of your correct mailing code, please call the laboratory. Failure to provide the proper mailing code may cause your report to be misrouted or delayed in processing.
Copies To	You can enter up to two additional address codes for duplicate copies of the reports, and we will mail them directly to your intended recipients (i.e., the Command BE, Base Civil Engineering, etc.). If you wish to do this, please call us prior to the first time, so that we can make sure your intended recipient is in our database and give you the correct address code to use.
Sample Collected By	Enter name (last name, first name, middle initial), grade, and AFSC of individual collecting the sample.
Signature	Enter the signature of the individual collecting the sample.
DSN	Enter DSN of responsible individual who can answer questions that may arise from the lab concerning the sample.
Reason for Submission	Specify the reason for sample collection and radionuclide you need specific analysis for. Also contact the lab if a particular action level is required. If analysis by a specific mode is desired, please specify with a brief justification. For example, please analyze by alpha spectroscopy for ^{234}U, ^{235}U, ^{238}U to distinguish naturally occurring uranium from depleted uranium contaminant. *If this is the initial baseline sample, please specify. You still need to specify the radionuclides that this individual is potentially exposed to. It is highly recommended that you contact the lab for guidance in determining what analysis to request. Contact lab customer service with any questions concerning analysis.*
Base Sample Number	Enter the eight-digit coded base sample number or DOEHRS sample ID.
Analysis Requested	Specify the radionuclide you need specific analysis for. If analysis by a specific mode is desired, please specify with a brief justification. For example, please analyze by alpha spectroscopy for ^{234}U, ^{235}U, and ^{238}U to distinguish naturally occurring uranium from depleted uranium contaminant. *If this is the initial baseline sample, please specify. You still need to specify the radionuclides that this individual is potentially exposed to. It is highly recommended that you contact USAFSAM/OEA for guidance when determining what analysis to request.*
Subject Name	Enter name of individual being sampled (last, first, middle initial).
Subject SSN	Enter the SSN of the individual being tested.
Height, Weight, Date of Birth, Sex, and Pregnancy Verification: Self explanatory.	
Route of Exposure	Selected the most likely route for the radionuclide to enter the body of the individual being sampled (i.e., inhalation, ingestion, wound/injection, or absorption).
Acute or Chronic Exposure Data	For acute exposures, enter the date and time (best estimate if not specifically known) of exposure. For chronic, relatively long duration exposures, enter the beginning date and ending date of the monitoring period.
Nuclide	Specify the nuclides that individual may have been potentially exposed to.
Inhalation Class and Chemical Form	Enter the inhalation class and chemical form appropriate for the operation being monitored. If unknown, contact the lab for guidance. 10 CFR 20 Appendix B is useful also for determining the class and form. In short, the Inhalation class is the lung clearance rate for the specific chemical form of the radionuclide. Class D refers to lung clearance rates of 0-10 days, Class W refers to lung clearance rates of 10-100 days, and Class Y refers to clearance rates greater than 100 days.
Particle Size	Estimate the activity median aerodynamic diameter (AMAD). The lab will use a default AMAD of 1µm if not specified or if the AMAD is unknown.
Comments	Enter any comments appropriate to the sample.

APPENDIX I: BASE CODES

CODE	BASE
0002Z	AIR FORCE ACADEMY
0003Z	LOS ANGELES AFB
0006Z	ALTUS
0008Z	ANDREWS AFB
0011Z	BARKSDALE AFB
0013Z	BEALE AFB
0021Z	JB ANACOSTIA-BOLLING
0025Z	GRISSOM ARB
0028Z	CANNON AFB
0030Z	FORT WORTH
0035Z	CHARLESTON AFB
0040Z	COLUMBUS
0047Z	DAVIS MONTHAN AFB
0050RZ	DOBBINS
0052Z	DOVER AFB
0054GZ	DULUTH ANGB
0055Z	DYESS AFB
0057Z	EDWARDS AFB
0058J	EGLIN AFB
0058Z	EGLIN AFB
0060Z	ELLSWORTH AFB
0063P	PETERSON AFB
0065Z	FAIRCHILD AFB
0067GZ	FORBES FIELD ANG
0071Z	FRANCIS E. WARREN
0072GZ	GENERAL MITCHELL FIELD
0076Z	GOODFELLOW AFB
0077Z	GRAND FORKS
0086Z	HILL AFB
0087Z	HOLLOMAN AFB
0088RZ	HOMESTEAD ARB
0093D	KEESLER AFB
0097Z	KIRTLAND AFB
0100AH	LACKLAND AFB
0100W	LACKLAND AFB
0101Z	LANGLEY AFB
0105Z	LAUGHLIN AFB
0107Z	HANSCOM AFB
0109Z	LITTLE ROCK AFB
0110GZ	RICHENBACKER ANGB
0114Z	LUKE AFB
0116Z	JB LEWIS-MCCHORD
0118Z	MCCONNELL AFB
0120Z	MACDILL
0121GZ	MCGUIRE AFB

CODE	BASE
0121Z	MCGUIRE AFB
0124Z	MALMSTROM AFB
0126RZ	MARCH ARB
0128Z	MAXWELL AFB
0131Z	MINOT AFB
0133Z	MOODY AFB
0136Z	MOUNTAIN HOME AFB
0138Z	NELLIS AFB
0139GZ	NIAGARA
0139RZ	NIAGARA ARB
0142GZ	FARGO ANG BASE
0146Z	OFFUTT
0156Z	PATRICK AFB
0157GZ	PEASE ANGB
0160Z	POPE AFB
0161GZ	PORTLAND
0163Z	RANDOLPH AFB
0168GZ	ROBINS AFB
0168Z	ROBINS AFB
0174Z	SCOTT AFB
0175GZ	SELFRIDGE ANGB
0177Z	SEYMOUR JOHNSON AFB
0178Z	SHAW AFB
0179P	SHEPPARD AFB
0181GZ	DELAWARE
0183GZ	STEWART
0184GZ	NEW YORK ANG
0186GZ	PHOENIX
0188Z	TINKER AFB
0190P	TRAVIS AFB
0190Z	TRAVIS AFB
0193Z	TYNDALL AFB
0194Z	VANCE AFB
0195Z	VANDENBERG AFB
0202RZ	WESTOVER
0203Z	WHITEMAN AFB
0206V	WRIGHT-PATTERSON AFB
0211GZ	ST PAUL ANGB
0211RZ	MINNEAPOLIS
0213GZ	QUONSET ANGB
0221GZ	FLORIDA ANGB
0227GZ	TULSA ANGB
0232GZ	EGG HARBOR ANGB
0235GZ	IDAHO ANG BASE
0242GZ	CHANNEL ISLAND ANGS

CODE	BASE
0248GZ	PITTSBURGH PA ANG
0248RZ	PITTSBURGH AFRB
0257GZ	LOUISIANA ANG
0257RZ	NAS JRB
0258GZ	DES MOINES ANG BASE
0273Z	HURLBURT FIELD
0280GZ	ILLINOIS ANG BASE
0282GZ	CHEYENNE ANG
0288GZ	162ND FIGHTER WING
0290GZ	BIRMINGHAM
0291GZ	WISCONSIN ANG BASE
0292GZ	VERMONT AIR NATIONAL
0306GZ	WEST VIRGINA ANG BASE
0311GZ	EAST GRANBY
0322GZ	BARNES ANGB
0324RZ	YOUNGSTOWN AIR RESERVE
0325GZ	FORT WAYNE
0327GZ	HANCOCK ANG
0329GZ	SIOUX
0331GZ	LINCOLN ANG
0333GZ	PEORIA ANG
0335GZ	BERRY FIELD ANG
0336GZ	164 AIRLIFT WING MEMPHIS
0337GZ	SWANTON
0338GZ	WILL ROGERS ANG BASE
0339GZ	THOMPSON FIELD ANGB
0342Z	BUCKLEY AFB
0347GZ	NEVADA ANG
0349GZ	MONTGOMERY ANGB
0350GZ	ST. JOSEPH ANGB
0352GZ	MANSFIELD ANGB
0355GZ	SALT LAKE CITY
0358GZ	FRESNO ANGB
0365GZ	ALPENA CRTC
0367GZ	SPRINGFIELD-BECKLEY ARPT
0375GZ	CHARLESTON ANGB
0377GZ	WILLOW GROVE ARS
0378GZ	SIOUX
0379GZ	MCENTIRE ANGB
0382GZ	CHARLOTTE

CODE	BASE
0406GZ	SAVANNAH IAP
0407GZ	LOUISVILLE
0417AH	NAS PENSACOLA
0422GZ	MIDDLETOWN
0428GZ	BATTLE CREEK ANGB
0436GZ	NYANG
0437GZ	KEY FIELD
0441GZ	BALTIMORE
0447GZ	BANGOR IAP
0450GZ	EBBING
0452GZ	KULIS ANG
0461GZ	MOFFETT FEDERAL AIR FIELD
0601P	RAMSTEIN AB
0608Z	KUNSAN AB
0621Z	SPANGDAHLEM AB
0631Z	LAKENHEATH AFB
0645Z	KADENA AIR BASE
0656Z	INCIRLIK AIR BASE
0658Z	AVIANO AIR BASE
0663Z	YOKOTA AB
0664P	JOINT REGION MARIANAS
0669Z	LAJES FIELD
0683Z	MISAWA AB
0686Z	EIELSON AFB
0687Z	ELMENDORF AFB
0688Z	JB PEARL HARBOR-HICKAM
0689Z	OSAN AB
0768M	MANILA
0770GZ	MUNIZ ANGB
1029GZ	KINGSLEY
1126Z	CHEYENNE MTN
1127Z	SCHRIEVER AFB
1297Z	MASIRAH ISLAND AB
1302Z	ALI AL SALEM
1303Z	AL DHAFRA AIR BASE
1309Z	MANAS AIR BASE
1317Z	AL UDEID AIR BASE
1443Z	BAGRAM AB
1446JC	FORT EUSTIS
1447Z	KANDAHAR AB

APPENDIX J: QUALITY CONTROL CHECKLIST

PLANNING	☐	Was the sampling objective clearly defined prior to sample collection (e.g., ensure compliance, select proper personal protective equipment (PPE), evaluate engineering controls, etc.)?
	☐	If the sampling was non-routine, was a laboratory Customer Service representative contacted to confirm analytical method, media, and specific shipping and handling requirements?
	☐	Were all physical states of the contaminant considered (gases, vapors, aerosols: dusts, fumes, mists, fibers, smoke, fogs, etc.)?
	☐	Was the contaminant of concern verified (verify via a MSDS, ESOH-MIS, etc.)?
	☐	Was the correct analytical method selected (verify via ASAGE and/or Customer Service)?
	☐	Does the type of media used match the media specified in the analytical method?
	☐	Did the sampling plan account for the presence of potentially interfering compounds?
SAMPLE COLLECTION, HANDLING, AND SHIPPING	☐	Will the lab receive the samples prior to the sample stability duration expiring?
	☐	Are the correct sample handling and shipping procedures being followed?
	☐	Was the employee's entire exposure captured?
	☐	Was the sampling narrative accurately documented with enough detail that the operation could be recreated if necessary including: hazardous chemicals, equipment, PPE, engineering controls, environmental conditions, etc.?
	☐	Was the DOEHRS Discoverer Viewer Sample Submission workbook completed properly including: ✓ Requestor name, signature, phone numbers, and email address? ✓ Do the physical sample IDs match the paperwork? ✓ Is the sample type correct (media blank, field blank, sample, etc.)? ✓ Is the collection date correct? ✓ Is the sample volume and collection time correct? Are all blank volumes reported as "0"? ✓ Is the correct analytical method shown on the discover report? ✓ Are the correct analyte(s) listed? ✓ Is the type of sample media listed in the comments? ✓ If the final report should be sent to multiple recipients, are their names listed in the comments?
	☐	Was the pump pre- and post-calibration information properly documented for each sampling pump including serial numbers, date, and flow measurements?
	☐	Were the pre- and post-calibration flow rates within 5%?
	☐	Were the sample volume and flow rate within the recommended range identified in the analytical method? If not, were deviations well documented and justified?
	☐	If particle size selective samplers were used (cyclone, IOM, button sampler, etc.), was the manufacturer's recommended flow rate used?
	☐	For low level detection, was the laboratory reporting limit used to determine the minimum required air volume?
	☐	Was the sampling conducted under the close guidance of a properly trained and certified individual IAW the 4B0X CFETP?
	☐	Were a sufficient number and type of blanks submitted to the lab?
	☐	If gravimetric sampling is being conducted (i.e., NIOSH 0500/0600), was preweighed/matched-weight media used?
	☐	If samples are being sent to a USAFSAM contract lab, was approval received prior to shipping?
RESULTS	☐	Was a letter written to the shop NLT 15 days after receipt of sample results or sooner IAW with specific expanded standards? Was a copy provided to the individuals sampled, wing safety, unit safety rep, union, and public health as necessary?
	☐	Were individual results loaded in DOEHRS, TWA calculated, and the IH SEG assessment updated?
	☐	Was the OEHED updated and briefed at the OEHWG and ESOHC as necessary?

APPENDIX K: AIR SAMPLING NARRATIVES

Table K-1 includes general observations that should be documented as part of an air sampling narrative. In addition to the general information, Table K-2 provides observations that should be documented specifically for painting, sanding, and blasting operations. For an example air sampling narrative, refer to *Consultative Letter, IOH-DO-BR-CL-2008-0029, Industrial Hygiene Program Support, Elmendorf AFB, Alaska.*

Table K-1. Basic Air Sampling Narrative Observations

GENERAL OBSERVATIONS
Date
Shop and organization
Building/room number
Operation being conducted
Hazardous materials used and % of contaminant of concern
Location of task (e.g., inside fuel cell #2)
Regulated area (Y/N)
Environmental conditions: temperature, pressure, relative humidity, wind
Analysis method (e.g., NIOSH 7300)
Sampling media, expiration date, and lot number
Type of sample collected (full period consecutive samples, partial period consecutive, etc.)
Name of personnel sampled
Name of sample collection personnel
PPE utilized (respirators, welding helmets, gloves, hearing protection, etc.)
Engineering controls (ventilation systems, vacuum sanders, welding curtains, etc.)
Air sampling pump and calibrator manufacturer, model, and serial number
Pre- and post-calibration measurements
Sample collection start and stop times
Total sample collection time (minutes)
Total sample collection volume
Sample numbers
Pictures of industrial operations (if possible)
Shipment and preservation information
Sample stability
Shipping information (carrier, tracking number)
Associated samples (bulk/wipe samples)
Potential interferences

Table K-2. Narrative Observations for Painting, Sanding, and Blasting Operations

PAINTING OPERATIONS
Weapon system
Paint type and National Stock Number
Pot pressure
Paint gun type (make and model)
Quantity sprayed
Duration of spraying
Additional equipment (electrostatic painting, etc.)
Worker characteristics: age, rank, years of experience painting at facility/weapon system/total years of experience.
Ventilation system characteristics: year built, size of booth (LxWxH), usage rate (per day/week), general flow rate, time since filters were last changed, filter change-out schedule.
Plenum design: Magnahelic/manometer installed? Where? Negative pressure maintained in booth? Laminar flow in booth? Areas of turbulent air? Where?
Work practices: Number of painters? If more than one painter, do painters avoid overspray from other painters? Aircraft painted supply side towards exhaust? Nose of aircraft pointed towards supply or exhaust? Body position – kept upstream of overspray, perpendicular to aircraft?
SANDING OPERATIONS
Pneumatic or hand sanding?
What type of sanding is being conducted (e.g., scuff sanding, bare metal, etc.)?
Does the sander have its own vacuum collection system?
Is it a random orbital ventilated sander?
Does it have a HEPA filter?
What is the rpm of the sander?
What is the operating pressure of the air flow of the vacuum sander?
What is the exhaust flow rate of the sander?
What is the size of the sanding pad?
What is the abrasive grit size?
What is being sanded?
Where is sanding conducted (open hangar, blasting booth, blasting cabinet, paint booth, outside, etc.)?
How often is the worker downwind of the sanding operation?
How close are the workers from each other while sanding?
How long was a worker sanding above his/her head?
Did the worker have to lie down to conduct the sanding operation under the aircraft?
Does the filter cassette contain loose pieces inside the cassette (i.e., is it overloaded)?
How often are the sanding pads changed?
BLASTING OPERATIONS
What item is being blasted?
What type of blasting media was used?
Does the operation occur in a booth or a cabinet?
What type/brand of air-fed helmet was used?
Does the filter cassette contain loose pieces inside the cassette (i.e., is it overloaded)?
Where was the air cassette filter placed on the person (inside or outside the helmet)?
Is blasting media allowed to accumulate on the floor until it is needed to refill the pot?
Was a bulk paint chip/media sample taken?
How does it compare to previous air sample results?
Blasting booth: year built, size of booth (LxWxH), general flow rate, usage rate (per day/week), location of exhaust vents, ventilation flow rate.